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Project Summary Report for Pilot-Scale Demonstration of Red Water Treatment by Wet Air Oxidation and Circulating Bed Combustion

October 1995
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Task Order No. 0005

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Prepared for:

U.S. Army Environmental Center
Aberdeen Proving Ground, MD 21010-5401

FINAL

PROJECT SUMMARY REPORT

FOR

PILOT SCALE DEMONSTRATION OF RED WATER TREATMENT BY WET AIR OXIDATION AND CIRCULATING BED COMBUSTION

VOLUME 4 OF 4

USAEC Contract No. DACA 31-91-D-0074
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As part of the Army's ongoing research and development program related to red water (K047) treatment, the U.S. Army Environmental Center (USAEC) contracted IT Corporation to prepare conceptual designs and plans for pilot scale demonstrations of two treatment technologies: wet air oxidation (WAO) and circulating bed combustion (CBC). The project objectives included development of a Test Plan and a Health and Safety Plan for these demonstrations. The Project Summary Report presents the conceptual designs. This Project Summary Report and the Test Plan and Health and Safety Plan are intended to serve as guides for development of complete project plans when the technology demonstration program is implemented. Because red water is not currently available for testing and the test site (host facility) where the demonstrations will be conducted has not been identified, these documents are intended to be generic in nature.

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Preface

As part of the U.S. Army's ongoing program related to the research and development of red water treatment technologies, the U.S. Army Environmental Center (USAEC) contracted IT Corporation to prepare conceptual designs and plans for pilot-scale demonstrations of two treatment technologies: wet air oxidation (WAO) and circulating bed combustion (CBC). The project objectives also included development of a Test Plan and Health and Safety Plan for these demonstrations, and preparation of a Project Report. This Project Report is intended to summarize the conceptual designs, Test Plan, and Health and Safety Plan and to serve as a guide for activities when the next phase of this program (i.e., conducting the demonstrations) is implemented.

Red water is not currently generated by the U.S. Army or any other part of the U.S. Department of Defense nor has it been generated in the recent past. An accurate and complete database does not exist in regard to the chemical and physical nature of red water. Due to this lack of waste characterization data, it was not possible to complete an accurate analysis of the associated testing and treatment requirements. Additionally, the source of red water for testing and the location where the tests will be conducted (i.e., the host facility) have not been identified. Therefore, waste- and site-specific concerns and requirements cannot be accurately or completely addressed at this time. As a result, this phase of the investigation included completion of plans and conceptual designs. Completion of system designs and finalization of test and safety plans must be completed in the future prior to initiation of the demonstration program.

This Project Report outlines the current project status and identifies the steps which must be completed prior to conducting the demonstrations. These include: selecting a host facility, obtaining red water for the demonstrations, characterizing the red water, preparing final process and equipment designs, finalizing Health and Safety and Test Plans, and acquiring the test equipment. Because of the unique and largely undocumented nature of red water, once a source has been identified, a critical initial objective will be characterization of the physical and chemical nature of the waste and a review of the associated treatment requirements.

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APPENDIX D

WET AIR OXIDATION VENDOR SURVEY SUMMARY

WET AIR OXIDATION

SUMMARY OF VENDOR CAPABILITIES

VENDOR: **AIR PRODUCTS, Inc.**

Bench Scale Capabilities:

Not Available

Pilot Scale Capabilities:

Not Available

Full Scale Units in Operation:

One system is currently successfully operating in the Netherlands. A full-scale demonstration facility is located in Colorado. The systems operate with a minimum waste stream of 1,000 gpm.

Comments:

The AIR PRODUCTS, Vertech Oxidation process utilizes a downhole reactor vessel which extends 4,000 to 5,000 feet into the ground. An oxygen source is added to the waste stream and the stream is pumped to the bottom of the vessel. The 4,000 to 5,000 foot column of water in the vessel provides the necessary pressure (approximately 1700 to 2200 psi).

The system is designed for treatment of municipal sewage sludge. Its application in treating industrial wastewaters has not been explored in great detail.

WET AIR OXIDATION

SUMMARY OF VENDOR CAPABILITIES

VENDOR: **KENOX, Inc.**

Bench Scale Capabilities:

Bench scale testing is conducted at a sub-contracted laboratory, Ortech, the largest accredited laboratory in Canada. Testing involves the use of autoclaves. Approximately 1 liter of test liquid required per test. Tests are typically conducted at 750 to 800 psi and 450 to 480 °F (230 to 250°C) range. Off gases and liquids are analyzed.

Pilot Scale Capabilities:

None at this time. Kenox is currently planning to develop two systems: a 2 liter/min pilot plant and a 1.5 gpm small scale treatment unit. The systems are expected to be available for short or long term leasing. However, no rental units are currently available, date of availability is unknown.

Full Scale Units in Operation:

Three full scale commercial plants are currently in operation. Several others are presently in the design stage. Operating ranges 1.5 to 300 gpm - 590 to 820 psi at 230 to 250°C, respectively.

Comments:

KENOX appears to be an emerging company with recent installation of WAO systems.

WET AIR OXIDATION
(Supercritical Water Oxidation [SCWO])

SUMMARY OF VENDOR CAPABILITIES

VENDOR: **MODAR, Inc.**

Bench Scale Capabilities:

Modar operates a test facility in Natick, MA, which has the capability of running a continuous process at 13 gpd or 500 gpd. Modar's SCWO process runs at temperatures of 400°C and above, and at pressures of about 3,400 psi. The bench-scale unit is not transportable. The unit is computer controlled and has on-line process effluent analyzers.

Pilot Scale Capabilities:

A skid mounted unit is available for field testing on a negotiated basis. The unit is capable of treating 500 gpd.

Full Scale Units in Operation:

One system, a 5,000 gpd unit, is currently due to be constructed early 1994 and be on line in early 1995. Pending successful operation of the 5,000 gpd unit, 20,000 and 100,000 gpd units may be constructed.

Comments:

MODAR, Inc. offers a Supercritical Water Oxidation (SCWO) technology which differs from WAO processes. According to personnel at Modar, the supercritical process is significantly more efficient than the WAO process in treating many industrial wastewaters. At typical process conditions of 620° C and pressures greater than 4,000 psi, less than 10 seconds is needed to achieve 99.99% destruction of organics.

WET AIR OXIDATION

SUMMARY OF VENDOR CAPABILITIES

VENDOR: **ZIMPRO, Inc.**

Bench Scale Capabilities:

Rocking autoclave system. Autoclave volumes - 500 to 750 ml (over 50 available). Operating range up to 3000 psi at 350°C. Temperature is computer controlled and monitored. Discharge gases measured then analyzed by GC.

Pilot Scale Capabilities:

Units located at ZIMPRO headquarters:
- 6 gph - titanium unit. 2000 psig to 315°C.
- 1 gpm - 316 stainless steel unit. 3000 psig to 343°C.

Portable Units:
- 6 gph - titanium unit. 2000 psig to 315°C. Skid-mounted.
- 5 gpm - low pressure (400 psig) thermal sludge thickening trailer-mounted unit.

Prices for renting the units are negotiable.

Full Scale Units in Operation:

Over 200 full scale units implemented and/or currently in operation. Most are municipal wastewater treatment systems. Approximately 35 are industrial wastewater applications. Implemented in U.S.A., Australia, Europe, Japan and Taiwan.

Comments:

Zimpro appears to be the leader in WAO in the U.S. Based on literature received from vendors, Zimpro appears to have the most WAO experience.

APPENDIX E

WET AIR OXIDATION TREATABILITY STUDY REPORT

KENOX CORPORATION

WET AIR OXIDATION PILOT PLANT

FOR

RED WATER

TREATABILITY STUDY REPORT

Prepared For:

IT CORPORATION
Cincinnati, Ohio

Kenox Project No. ***UJ41014***
Purchase Order No. ***483392***

July 1995

1.0. Executive Summary

The U.S. Army Environmental Center (USAEC) contracted IT Corporation (IT) to prepare conceptual designs and planning documents for pilot-scale evaluations of TNT red water treatment by wet air oxidation (WAO) and circulating bed combustion (CBC). IT subsequently contracted Kenox Corporation to conduct limited WAO bench-scale treatability testing and prepare the WAO conceptual design.

Kenox Corporation subsequently prepared an autoclave test plan (Appendix A). The objectives of the bench-scale treatability test were to (1) demonstrate the feasibility of WAO of TNT red water under the Kenox typical operating temperature range, and (2) determine the design parameters for the WAO pilot plant (i.e., WAO reaction temperature, pH of feed and residence time).

The study was carried out by (1) Leigh Analytical Services Ltd, United Kingdom and (2) TNO Institute of Environmental and Energy Technology, The Netherlands on samples of TNT red water obtained from a European military ammunitions production plant. Due to the limited amount of waste water available, the number of test runs and the quantity of analyses specified in the original test program (Appendix A) had to be reduced (i.e. analyses for nitroaromatics and DNTS' compounds were removed from the program). The results of the condensed test program are summarized as follows:

- At a reaction temperature of 250 ^{o}C, catalyst addition of 0.5 g/L $CuSO_4$ and pH adjustment to 4, overall COD removal was 88 %.
- Decreased nitrite level at the end of WAO indicated oxidation of nitrite to nitrate.
- Increased sulfate level at the end of WAO indicated the oxidation of inorganic sulfite or the desulfonation of SO_3 groups associated with DNTS' and other sulfur bearing organic compounds in the red water.
- The detailed descriptions of the treatability program and the results are discussed in Sections 2, 3 and 4.

2.0. Treatability Test Program

2.1. WAO Autoclave Test Runs

Due to the limited amount of TNT Red Water available, the WAO treatability test program was shortened from the proposed treatability test program outlined in Appendix A. The condensed treatment program, listed in Table I below, was conducted to demonstrate the feasibility of WAO of TNT red water under the Kenox typical operating temperature range and to determine design WAO process parameters to be used as the design basis for the pilot plant (i.e. pH level, temperature and residence time).

Based on Phull's study (1992) higher overall oxidation rates were observed at low pHs. Thus the pH of the feed was adjusted to 4 -5 using sulfuric acid.

TABLE I: Treatment Program

Test No.	*Oxidant*	*Reaction Temperature deg C*	*pH*	*Catalyst Addition*
1	Air	250	4	Yes
2	Air	250	5	No

Test # 1 was performed by Leigh Analytical Services in U.K. and test # 2 was performed by TNO Institute of Environmental and Energy Technology in The Netherlands.

2.2. Analytical Determinations

The times and type at which the treated samples were collected in each test, and the analytical parameters untreated sample and these treated samples are defined in Table II. For ease of reference, the analytical parameters and their analytical methods are grouped in three schedules as outlined in Table III.

TABLE II: Sample and Analytical Parameters Matrix

Test No.	*Sample Matrix*	*Collection Times, minutes*	*Analytical Schedule*
Raw Waste	Liquid	n/a	1 & 2
1	Liquid	0	COD only
		90	COD only
2	Liquid	0	1
		30	1
		60	1
		90	1 & 2
	Gas	90	3

TABLE III: Grouping of Analytical Parameters.

SCHEDULE 1		SCHEDULE 2		SCHEDULE 3	
Parameters	Analytical Methods	Parameters	Analytical Methods	Parameters	Analytical Methods
pH	SM No. 4500-H	TOC	SM No. 5220-D	CO	GC
COD	SM No. 5220-D	TS	SM No. 2540	CO_2	GC
Color		TVS	SM No. 2540	NO	Infrared Spec.
		Nitrite	SM No. 4500	NO_2	Electrochemical Sensor
		Nitrate	SM No. 4500	N_2	GC
		Sulfate	ASTM D4327-91	NH_3	Infrared Spec.
				SO_2	Infrared Spec.

3.0. Autoclave Operating Procedures

The details on the experimental procedures are described below.

3.1 Leigh Analytical Services Ltd, U.K.

- The pH of the raw waste was adjusted to approximately 4 using sulphuric acid. The pH of the raw waste was not measured at that time, however, it is expected that the pH should fall in the range of 8.3 as measured at time of test # 2.
- A copper catalyst at a concentration of 0.5 g/L expressed as $CuSO_4$ was added to the pH adjusted waste.
- One liter of the above feed solution was charged to the autoclave and the autoclave was then assembled.
- The autoclave was pressured up to 750 psig using air.
- Air flow rate was adjusted accordingly.
- The mixer and the heater were set to the appropriate set points.
- When the reactor reached the set temperature, time was set to T = 0 minutes.
- At T = 90 minutes, the autoclave was cooled as quickly as possible and a liquid sample was taken for COD measurement.

3.2 TNO Institute of Environmental and Energy Technology, NL

- The original sample as received was analyzed per Schedules 1 and 2.
- The pH was adjusted to approximately 5 with dilute sulphuric acid from an original pH of 8.3.
- Copper catalyst was not added to the feed solution.
- 500 ml of the feed solution was charged to the 1 litre autoclave and the autoclave was then assembled.
- To prevent reducing conditions during the system heating up time, 50 psig of air was charged to the autoclave. The reactor was then heated up to 250 ^{O}C.
- Due to the inability of the test equipment to withdraw intermittent liquid samples, four separate test runs were conducted with residence times of 0, 30, 60 and 90 minutes. T = 0 min. was considered at the point at which 250 ^{O}C had been reached.
- At T = 0 min., the stirrer was set to the appropriate speed.

- At the end of each test residence time, a 100 ml liquid sample was extracted from the sample port located at the bottom of the reactor. The liquid sample was analyzed per Schedule 1.
- The stirrer was then turned off and the reactor cooled down and discharged.
- In the case of the 90 minutes test run, a gas sample was taken and placed in a sample bomb. The sample was analyzed per Schedule 3.

4.0. Results and Discussion

4.1. Feed Characterization

Table IV shows the analytical results obtained from the raw waste water as received. The characterizations of the anticipated TNT Red Water are also included in this table for reference.

COD was measured at 3,000 mg/L at Leigh and 3,210 mg/L at TNO. This COD level is considerably lower than what has been reported in literature (i.e. characteristics of red water based on data from the Radford Army Ammunitions Plant (1988) and analyses performed on red water from ICI Canada (1992)). Red water composition is known to vary with crude TNT composition, purification conditions and overall process operating condition. The measured pH of 8.3 falls within the typical red water pH range of 7.0 to 9.7.

4.2. COD/TOC/Total Solids/Nitrite/Sulfate Analyses

4.2.1 Test # 1:

Test #1 was a based line run to determine the maximum COD conversion on this particular TNT sample at the conditions performed by Phull, i.e., initial acidic pH and with catalyst addition.

This test demonstrated an overall COD reduction of 88 % with a starting COD of 3000 mg/L and an ending COD of 350 mg/L at time T=90 minutes . The oxidation temperature was 250 ^{O}C, and homogenous catalyst in the form of copper sulfate was added at a rate of 0.5 g/L. Since only COD measurement was performed for this test, observation and discussion on other parameters are not possible.

4.2.2 Test # 2:

- COD results:

1. The COD measurement performed in test # 2 was soluble COD (SCOD) not total COD as measured in test # 1; however, there is little difference in the measured COD values of the raw waste from both tests (3000 mg/L in test # 1 and 3210 mg/L in test # 2). This difference is within the COD measurement range of ±5 %. Furthermore, the measured percent of Total Solids (TS) is only 0.83%; hence, one can assume that for this particular TNT Red Water sample, the COD contribution from the Total Suspended Solids is insignificant and the measured SCOD can be used as total COD.

2. The increase of COD after the pH adjustment of the raw feed is possibly due to an anomalous COD measurement or other reaction generated by sulfuric acid.
3. As shown in Table V, at time T=0 , a COD reduction of 96.8 % was reached. This is because oxidation has occurred during the long heating and cooling period of the sample. At TNO 's laboratory, the heating period of sample from ambient temperature to 250 C varies from 50 to 75 minutes. When the desired residence time has been reached, the liquid is cool down during a period of 75 minutes.
4. There were insignificant changes in measured COD at the residence times of 30, 60 and 90 from time t=0. Again this is due to the long heating and cooling time as explained in 3 above, and maximum COD conversion has been exhausted.

- TOC decreased by 59 %.
- Total solids decreased by 28 % . However, TVS remained about the same after WAO. Organic compounds may have been converted to organic byproducts versus being oxidized to CO_2.
- Nitrite decreased by 99.8 %. As the nitrate wasn't measured at 90 minutes, it is assumed that the nitrite was oxidized to nitrate.
- Sulfate level increased by 44% indicating the oxidation of inorganic sulfite or the desulfonation of SO_3 groups associated with DNTS' and other sulfur bearing organic compounds in the red water.

4.3. *pH Reduction/Color Change*

The pH of the waste water in all four test runs conducted at TNO dropped from 5 to an average of 2.9. The final pH agreed well with WAO test runs conducted by Phull (1992). Phull's WAO test runs on red water conducted at reaction temperatures of 225 ^{o}C and 300 ^{o}C, showed final pH values of 3.1 and 2.8 respectively after 60 minutes reaction time.

The low pH of the oxidized solutions supports the conceptual design decision to proceed with titanium as the material of construction for the WAO reactor and associated process equipment and piping since the corrosivity of wastes is aggravated under such conditions.

The TNO test runs showed that the color of TNT red water changed from reddish brown to light yellow after WAO. This observation agreed with Phull's observation for a WAO test run conducted at the same temperature range.

4.4. *Offgas Results*

Due to a temporary malfunction of TNO's gas sampling facilities, off gas analyses were not performed.

TABLE IV : Characterization of Untreated TNT Red Water

Parameters	TNT Red Water used in This Study	Anticipated TNT Red Water from RAAP
pH	8.3	7 - 9.7
COD, mg/L		65,000 - 120,000
COD, mg/L - Leigh	3000	
COD, mg/L - TNO	3210	
Total Organic Carbon, mg/L	1200	
Total Solids, %	0.83	15 - 30
Total Volatile Solids, % TS	57	
Nitrite, mg/L	50	6788
Nitrate, mg/L	64	1739
Sulfate, mg/L	2150	

TABLE V: Autoclave Results of Run # 2

Reactor Temperature = 250 ^oC *pH Adjusted to 5* *Oxidant = Air*								
Time (min.)	**pH**	**COD (mg/L)**	**TOC (mg/L)**	**TS (%)**	**TVS (% TS)**	**Sulphate (mg/L)**	**Nitrite (mg/L)**	**Nitrate (mg/L)**
Raw sample	8.3	3210	1200	0.83	57	2150	50	64
Raw sample after pH adjustment	4.93	3659						
0	2.96	116						
30	2.82	113						
60	2.91	124						
90	2.90	136	490	0.6	78	3100	0.09	n/a

APPENDIX A

1.0 INTRODUCTION

Several independent studies have been conducted to evaluate the potential technologies for treatment of TNT red water during the past 15 years. The results of those studies indicated that WAO is one of the feasible technologies for TNT red water treatment. The objective of this treatability study is to quantify the effects of different conditions on Kenox WAO efficiency to treat TNT red water and to generate data for conceptual design of such a Kenox system.

2.0 WASTE SAMPLE REQUIREMENTS

The treatability study program outlined in section 5.0 will be performed assuming sufficient red water is available.

3.0 WASTE SAMPLE CHARACTERIZATION

The raw waste sample shall be analyzed for the following parameters:

1. pH
2. Total Solids
3. Total Volatile Solids
4. COD
5. TOC
6. Inorganics Salts
7. Alpha - TNT
8. 2,4 - DNT
9. 2,6 - DNT
10. 1,3,5 - TNB
11. 1,3 - DNB
12. DNT Sulfonates
13. Chlorides
14. Metal Scan
15. Nitrite
16. Nitrate
17. Sulfate

4.0 SAMPLE STORAGE

All raw and treated samples shall be placed in dark bottles and stored in a refrigerator at 4°C. Extra treated samples shall be kept in storage for future reference.

5.0 TREATMENT DETERMINATIONS

Information on kinetics and oxidation reaction mechanisms indicate pH and temperature can influence the reaction rate. Experiments are contemplated for this waste stream to observe the pH effect and the temperature effect on the WAO performance. The homogeneous catalyst effect on the WAO performance is also to be determined.

Overall, the treatability experiments will be performed in batch operations of an WAO autoclave using air as the oxidant. There will be a total of five (5) runs for this stream. Wet air oxidation tests shall be performed as outlined in the table below.

Run No.	Reaction Temperature deg C	pH	Homogeneous Catalyst Addition
1	250	As is (7 - 9.7)	No
2	250	5	No
3	250	Best of runs 1,2*	Yes
4	230	Per run 3	Best of runs 1,2,3*
5	Best of runs 1,2,3,4*	Per run 3	Best of runs 1,2,3*

*Best selection is based on COD and TOC reduction, after consultation with Kenox.

pH Effect:

Most of the wastes oxidize well under acidified conditions. However, some wastes may be more receptive to the WAO under the alkaline conditions. To investigate the effect of pH on the oxidation reaction of this waste stream, two (2) runs at autoclave temperatures of 250°C will be conducted for "as is" sample (i.e. pH= 7 - 9.7) and sample with pH adjusted to about 5 using sulfuric acid.

Homogeneous Catalyst Effect:

Run #3 will investigate the homogeneous catalyst effect with starting pH level selected from the pH runs.

Temperature Effect:

Run #4 will investigate the effect of temperature on reaction kinetics at the best selected pH level from the pH runs and with or without the addition of catalyst based on Run #3 results.

Duplication Run:

Run #5 will duplicate the run at the best combination of temperature, pH and catalyst effect.

6.0 ANALYTICAL DETERMINATIONS

The required analyses are grouped in the following schedules:

SCHEDULE 1	SCHEDULE 2	SCHEDULE 3	SCHEDULE 4
Liquid	**Liquid**	**Liquid**	**Gas**
COD		COD	CO
TOC		TOC	CO_2
pH		pH	NO
	TVS	TVS	NO_2
	chlorides	chlorides	N_2
	total solids	total solids	NH_3
	inorganic salts	inorganic salts	SO_2
	DNT sulfonates	DNT sulfonates	
	alpha - TNT	alpha - TNT	
	2,4 DNT	2,4 DNT	
	2,6 DNT	2,6 DNT	
	1,3,5 TNB	1,3,5 TNB	
	1,3 DNB	1,3 DNB	
	Nitrite	Nitrite	
	Nitrate	Nitrate	
	Sulfate	Sulfate	
		Metal Scan	

For each of the 5 test runs, liquid samples will be drawn at times, T = 0, 30, 60 and 90 minutes. The gas mixture in the head space of the autoclave will be cumulatively collected during each entire run. The liquid samples and gas samples shall be subjected to the above analytical schedules as follows:

- Raw waste sample shall be analyzed as per Schedule 3.
- For runs 1, 2 and 3, liquid samples collected at T = 0, 30, 60 and 90 minutes shall be analyzed per Schedule 1.

- On the basis of COD and TOC results, the best performing run from runs 1, 2 and 3 shall have its liquid samples collected at T = 0, 30, 60 and 90 minutes from this run analyzed per Schedule 2.
- For runs 4 and 5, all liquid samples collected from these two runs shall be analyzed per Schedules 1 and 2.
- Offgas samples from run 4 and the best performing run from runs 1, 2, and 3 shall be analyzed per Schedule 4.

APPENDIX F

CIRCULATING BED COMBUSTION TREATABILITY STUDY REPORT

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FLUIDIZED-BED AGGLOMERATION TENDENCIES DURING THE INCINERATION OF SURROGATE RED WATER

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FLUIDIZED-BED AGGLOMERATION TENDENCIES DURING THE INCINERATION OF SURROGATE RED WATER

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INTRODUCTION

BACKGROUND

International Technology Corporation (IT Corp.) authorized Hazen Research, Inc. to perform a study to evaluate fluidized-bed agglomeration tendencies while incinerating a surrogate red water. Actual red water is a highly toxic, RCRA-regulated, hazardous waste and is not available for testing. Therefore, a laboratory-prepared surrogate which is not RCRA hazardous was used for this testing. The study was limited to testing two fluidized-bed materials: zircon sand and brown alumina.

Red water is a waste stream produced in the selliting process from the manufacture of trinitrotoluene (TNT). The spent sellite solution is a deep red color (red water) and contains between 15 and 30% solids, of which about 45% are sodium salts as sodium sulfite, sulfate, nitrite and nitrate and 55% are sulfonated derivatives of the unsymmetrical TNT isomers. "Red water ... has been either burned in rotary kiln separators or sold to the paper industry. These options are no longer viable, and alternative approaches are under study including process changes and modifications of current incineration technology" according to the reference cited below.[1]

It is anticipated that thermal treatment of red water in a circulating or fluid-bed combustor will cause agglomeration of common bed materials, due to the buildup of sodium salts in the bed. The sodium salts melt and become sticky at elevated temperatures, causing the bed particles to adhere to one another, thus forming larger particles. A purge of fresh sodium-free bed material to the bed is needed to maintain the sodium salt in the bed at a level which can be tolerated. Operating bed temperature must be maintained below a point at which the bed becomes so sticky that defluidization occurs.

PROGRAM OBJECTIVES

The objectives of the bench-scale fluidized-bed tests were to:

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1 Kirk-Othmer Encyclopedia of Chemical Technology, Fourth Edition, v. 10, p. 39.

- Evaluate fluidized-bed agglomeration tendencies while incinerating surrogate red water.
- Obtain particle size data on bed products to quantify the agglomeration tendencies.
- Obtain data on the sodium content of the bed products.
- Evaluate the mineralogy of the final bed to identify the depositions on the bed material particles.

PROGRAM OPERATIONS

Testing was done on February 21, 22, and 23, 1995. This program was witnessed by Mr. Prakash Acharya, representing IT Corp. Operations were supervised by Mr. Steven D. Will, the fluidized-bed system data were monitored and recorded by Mr. Thomas Pinnow, and the feed system and ash product collection were also monitored and recorded by Mr. Thomas Pinnow. Mr. Rodney Hodgson provided technical expertise.

SUMMARY

The original test plan called for evaluating surrogate red water incineration at 807°C in a fluidized bed with two different types of bed materials: zircon sand and alumina. Two concentrations of the surrogate red water were to be tested, 15% and 30% solids. After the first day of testing, it became apparent that maintaining a fluidized bed at 870°C was impossible with sodium salts present in the bed; the fluidized-bed materials would become sticky and the bed would defluidize. Salts would precipitate out of the 15% solids surrogate red water solution after a short period of time. It was agreed that the 30% solids solution would be even more difficult to maintain in solution, so it was not tested at this time.

After the first day of testing, the test plan was adjusted to reflect these findings. The revised plan called for operation at 650°C while feeding salt solution with no organic salts for 90 minutes, (Base Case 1), followed by operation at 650°C while feeding surrogate red water for 90 minutes, (Base Case 2). Following Base Case 2, the bed temperature would be increased at 50°C increments until defluidization occurred. During all operations, fresh bed material would be continuously fed to the vessel and bed overflow would be continuously withdrawn.

Table 1 summarizes the bench-scale fluidized-bed operating parameters. The test results indicate that incineration of surrogate red water tends to agglomerate both the zircon sand and alumina bed materials, even at low temperatures of 650°C. Bed defluidization occurred as temperatures in the bed approached 800°C.

During testing of both bed materials, carbon monoxide (CO) emissions decreased as the temperature increased. The CO emissions in the process offgas were generally lower while the surrogate red water in the brown alumina bed material was incinerated. A possible reason for the lower CO emission could be the greater amount of fines in the alumina bed material than in the zircon sand material. The brown alumina contained 4.7% material of less than 200 mesh, compared to 0.8% less than 200 mesh in the zircon sand. This increased loading of fines in the freeboard above the bed carried more mass into the freeboard, and so increased combustion of CO.

In all of the tests, nitrogen oxide/dioxide (NO_x) was present in the process offgas, probably due to the thermal decomposition of sodium nitrite and sodium nitrate in the surrogate red water. The NO_x emissions were basically the same when incinerating the sodium salt solution without organic salts or the surrogate red water. The addition of limestone to the bed did not reduce the NO_x emissions.

Table 1. Summary of Bench-scale Fluidized-bed Testing Operating Parameters

Testing on February 22, 1995

Fluidized Bed Material	Test Designation Number	Solution Feed Material	Solution Feed Rate, gm	Fluid Bed Temp., °C	Test Period Time, hr	Bed Feed Rate, gm	Bed and Cyclone Product gm		Bed Overflow: Particle Size % > 70 M	Bed Overflow: Sodium Content % by wt.	Offgas Composition: NO_x ppm	SO_2 ppm	CO ppm	THC ppm	O_2 %	CO_2 %
Zirconia Sand	Base Case 1	Salt Only	8.0	645	1.5	51.0	51.7		10.9	0.34	1840	3	6	0	20.5	0.0
Zirconia Sand	Base Case 2	Surrogate	8.6	652	1.5	53.0	53.3	*	4.6	0.42	1768	3	464	5	19.8	0.9
Zirconia Sand	Test 1	Surrogate	9.0	692	1.0	51.9	51.3		4.6	0.40	1773	3	407	0	19.7	1.0
Zirconia Sand	Test 2	Surrogate	8.9	745	0.5	54.7	34.2		12.3	0.50	2040	3	258	0	19.7	1.0
Zirconia Sand	Test 3	Surrogate	8.4	772							Defluidization Occurred					
Average Value			8.6			52.6	47.6				1855	3	284	1	19.9	0.7

* Visible carbon in ash

Testing on February 23, 1995

Fluidized Bed Material	Test Designation Number	Solution Feed Material	Solution Feed Rate, gm	Fluid Bed Temp., °C	Test Period Time, hr	Bed Feed Rate, gm	Bed and Cyclone Product gm		Bed Overflow: Particle Size % > 70 M	Bed Overflow: Sodium Content % by wt.	Offgas Composition: NO_x ppm	SO_2 ppm	CO ppm	THC ppm	O_2 %	CO_2 %
Alumina	Base Case 1	Salt Only	8.7	645	1.5	36.3	33.4		8.4	0.45	1746	2	6	0	20.5	0.0
Alumina	Base Case 2	Surrogate	7.5	650	1.5	40.3	33.2	**	5.4	0.49	1500	2	290	1	19.9	0.8
Alumina	Test 1	Surrogate	8.9	697	1.0	43.0	38.5		6.3	0.55	1894	2	347	1	19.7	1.0
Alumina	Test 2	Surrogate	7.7	745	0.9	43.5	58.0		8.0	0.37	1633	2	189	0	19.9	0.7
Alumina	Test 3	Surrogate	7.9	804	0.6	47.6	48.3		11.3	0.31	1626	2	25	0	20.0	0.8
Average Value			8.1			42.2	42.3				1680	2	171	0.4	20.0	0.7

** No carbon visible in ash

ppm = Parts per million (volume) THC (total hydrocarbon) on wet basis. All other gas compositions measured on dry basis.

No sulfur dioxide (SO_2) was measured in the process offgas. None was expected, since the thermal decomposition of sodium sulfate and sulfite does not occur at the operating temperatures tested.

Examination of the final bed samples by microprobe x-ray diffraction showed a thin coating of a sodium sulfate salt on the particles. Photographs are presented in the results section of this report, showing how the individual particles had become glued together.

RECOMMENDATIONS

It is recommended that the incineration of the surrogate red water be tested in a circulating bed combustor (CBC). In a CBC, the bed material is moving at a much higher rate, which may reduce the agglomeration tendencies of the bed material and the possibilities of defluidizing the bed. It may be possible to operate at temperatures up to 850°C without encountering defluidization problems. However, ash stickiness may cause problems in the cyclone underflow of the CBC where the velocity of the bed material is slowed down before it reenters the combustor. Cooling of the cyclone underflow material may make it less sticky and allow it to flow more easily. Introduction of fresh bed material into the cyclone may be an effective way of cooling the cyclone underflow as well as diluting the concentration of sodium at that point.

Continuous withdraw of agglomerated bed will almost certainly be required to maintain a sodium level in the bed which can be tolerated. This agglomerated bed material, however, could be recycled by a washing, screening, and drying circuit before it is reintroduced to the bed.

PILOT PLANT DESCRIPTION

Hazen's four-inch-diameter, externally heated, fluidized-bed test facility was used for the red water incineration program. This facility included a four-inch-diameter 310 stainless steel fluid-bed vessel, external cyclone, and baghouse with five-micron porous metal filters. An offgas scrubber with recirculating caustic (NaOH) solution was employed to neutralize the acid gases before they were exhausted to the atmosphere. A schematic of the system is provided as Appendix A of this report.

The fluidized-bed vessel was encased in an insulating shell equipped with electrical resistance heating elements to preheat the fluid bed and to maintain operating temperatures during testing. The total reaction length of the furnace was 32 inches from the air distribution plate to the furnace lid. The distribution plate, containing 34 orifices (0.044 inch diameter each), was welded to a windbox which rested on a small lip toward the bottom interior of the vessel. Liquid feed was introduced to the bed through a vertical, 1/4-inch tube which was welded to the center of the distribution plate and extended downward through a tee at the bottom of the windbox feed pipe. An air purge was maintained at all times to keep solids from the bed entering the tube. A one-inch bed underflow port was located just above the distribution plate, which remained closed during most of the testing. A one-inch bed overflow (BOF) port, located at a fixed height of nine inches above the distribution plate, was used for collecting bed products. Bed and cyclone samples were collected continuously in separate canisters. The contents of the bed canister were recovered at 30-minute intervals, then weighed, bagged, and labeled.

A dry solids feed tube, a thermowell, and a bed pressure tap were positioned through the roaster lid. The thermowell extended to a point 3/4 inch above the distribution plate, the pressure tap extended 1-3/4 inch above the plate, and the feed tube extended to within 3-3/4 inches of the plate.

Process temperatures were measured by two thermocouples positioned in the fluid-bed zone, and by three additional thermocouples placed in the freeboard, cyclone outlet, and baghouse outlet, one in each location. Gauges measured direct pressure in the freeboard, and differential pressures across the bed, cyclone, and baghouse. Flowmeters were used to measure and control air flow that fluidized the bed and transported the bed material and red water into the bed.

Fresh bed material was introduced to the fluidized bed, using a screw feeder. The metered feed discharged from the screw and passed through the 1/2-inch-diameter stainless steel tube that

extended into the fluid bed. Air (about 0.4 standard cubic feet per minute) was used to assist in the transport of the feed through the tube and into the fluid-bed zone.

The process exhaust gas was sampled at the baghouse outlet and analyzed continuously for O_2, CO_2, CO, SO_2, NO_x, and total hydrocarbons (THC). The gas sample was filtered and cooled to remove entrained particulate matter and water vapor before the gas entered the analyzer. The THC analyzer received a filtered hot sample. The specific gas analyzers used in the continuous emission monitor (CEM) for this program are listed in Appendix A.

Temperatures and exhaust gas composition were continuously recorded using a Molytek data acquisition system and computer. Printouts of the data and plots of temperature and offgas emissions are provided in Appendix B of this report. Operational data were recorded at 30-minute intervals on logsheets, and comments concerning the operation of the system were recorded in a journal. These logsheets and journal entries are also provided in Appendix B of this report.

The final ash products were collected in sealed steel canisters and removed at regular intervals during the operation. A ball valve isolated the canister from the kiln to prevent air leakage into the incinerator and to prevent accidental discharge of hot material from the bed while the canister was being removed.

PROCESS MATERIAL DESCRIPTION

RED WATER SURROGATE

The surrogate red water was prepared according to the recipe shown in Table 2. Three-liter batches were prepared as needed. The sodium salts were first completely dissolved in 40% of the required quantity of water. The 3,5-dinitrobenzoic acid was mixed in 60% of the required water. Because the pH of the salt solution was about 14 and the pH of the acid mixture was about 2, the acid was neutralized to about a pH of 5 with the addition of a 50% solution of sodium hydroxide. The neutralization was necessary to dissolve the solids and to prevent generation of gas and heat when the acid and the base solution were mixed. About 50 grams of 50% sodium hydroxide solution was necessary to neutralize each three-liter batch or about 0.8% NaOH by weight. When the neutralized acid solution was mixed with the sodium salt solution, the resulting solution turned a deep red color.

Table 2. Red Water Surrogate Solution Recipe

Constituent	15% Solids Solution[1]		30% Solids Solution	
	Percent of Total	3-liter batch grams	Percent of Total	3-liter batch grams
Water	85	2550	70	2100
3,5-Dinitrobenzoic Acid	7.8	234	15.7	471
Sodium Sulfite	2.6	78	5.1	153
Sodium Sulfate	2.6	78	5.1	153
Sodium Nitrite	1.8	54	3.6	108
Sodium Nitrate	0.2	6	0.5	15
Total	**100**	**3000**	**100**	**3000**

[1] The 15% solution required the addition of 50 grams of a 50% solution of sodium hydroxide and water to each three-liter batch.

A salt would begin to precipitate out of the solution after about an hour; a mixer was used to keep the salts in suspension. The solution was fed from a one-gallon plastic bucket using a peristaltic metering pump (roller tube pump). The feed bucket was placed on a electronic laboratory weigh scale. The feed rate was measured by the loss of weight of the contents of the bucket.

ZIRCON SAND BED MATERIAL

The zircon sand bed material was obtained from the AGSCO Corporation in Hasbrouck Heights, New Jersey. The sand is a heavy mineral sand with a bulk density of 2.645 grams per cubic centimeter or 165 pounds per cubic foot used as a foundry material or for fluid bed use with a melting temperature of 2100 to 2300°C. Its typical mineral composition is shown below in Table 3.

Table 3. Zircon Sand Mineral Composition

Mineral Compound	Chemical Formula	% by Weight
Zircon	$ZrSiO_4$	95.0
Aluminum Silicate	Al_2SiO_2	3.0
Rutile	TiO_2	2.0
Total		**100**

In appearance, the zircon sand was a light tan color, free flowing and free of dust. Its particle size distribution is shown in Table 4.

Table 4. Zircon Sand Particle Size Distribution

Retained on Mesh Size	Weight % Retained
70 US mesh	0.3
100 US mesh	11.0
140 US mesh	67.4
200 US mesh	20.5
Less than 200	0.8

ALUMINA MATERIAL

The alumina bed material was also obtained from the AGSCO Corporation in Hasbrouck Heights, New Jersey. This material, known as brown alumina, is used as a grinding media and for fluidized beds. The crystal form of the material was alpha alumina and was amphoteric in nature. The material had a melting temperature of about 2000°C. The typical mineral composition is shown below in Table 5.

Table 5. Brown Alumina Mineral Composition

Mineral Compound	% by Weight
Al_2O_3	95.6
TiO_2	2.67
SiO_2	1.60
ZrO_2	0.35
Fe_2O_3	0.25
MnO_2	0.11
CaO	0.25
MgO	0.11
P_2O_5	0.05
SO_3	0.04
Alkali	0.05

Two grit sizes, 90 and 150, were blended together in equal weight proportions to yield a material with approximately the same size distribution as the zircon sand. Shown below in Table 6 is the resulting size distribution of the mixture.

Table 6. **Blended Brown Alumina Particle Size Distribution**

Retained on Mesh Size	Weight % Retained
70 US mesh	0.12
100 US mesh	35.51
140 US mesh	24.24
200 US mesh	36.40
less than 200	4.74

This mixture had a bulk density of 1.91 g/cc or 119.2 lb/cf.

ROTARY KILN TEST PROCEDURE AND DISCUSSION

FEBRUARY 21, 1995 - TESTING AN ALUMINA BED

The original test plan called for testing the incineration of surrogate red water in a fluidized bed held at 870°C (1600°F). Both alumina and zircon sand beds were to be tested while 15% and 30% solids solutions of surrogate red water were fed.

On February 21, 1995, the four-inch fluid-bed vessel was preheated to 870°C before 4,000 grams of blended (90 grit and 150 grit at a 1:1 ratio) alumina bed material was added to fill the vessel to a nine-inch deep static bed. The fluidized bed was allowed to reach 870°C. The bed overflow and cyclone canisters were collected at 0851 hours. A total of 2,300 grams of material was collected, leaving 1,700 grams of fluidized material in the vessel. At 0855 hours, fresh bed material was metered into the fluidized bed at 33 grams per minute (gm). The 15% solids red water surrogate was started at 0911 hours at a rate of 6.4 gm. By 0917, the NO_x concentration in the process offgas climbed to about 1,800 ppm. At 0925, a blend of 90% fresh alumina and 10% limestone was metered into the bed. With the addition of limestone to the bed, an initial reduction of NO_x was noticed, but this was only temporary as the NO_x quickly rose back to its previous levels of 1,800 to 2,000 ppm. An increase in CO_2 was observed due to the calcination of the limestone. The first bed overflow sample taken at 0930 showed signs of agglomeration. The feed rate of red water was increased until fluidized-bed temperatures showed a slight decreasing trend, a sign that a maximum red water feed rate had been obtained.

At 0959 hours, the bed differential pressure gauge went to zero and the two bed thermocouples showed a significant temperature differential, an indication the bed had defluidized. The red water and solids feed were shut off. Some bed underflow was removed and the fresh bed feeder was restarted. A rod was inserted into the vessel to mechanically stir the bed. The bottom of the vessel was struck with a hammer to help regain fluidization. At 1019, fluidization was regained; by 1026 hours there was no bed temperature differential, and red water feeding was restarted at about 8.5 gm. Operation continued for 38 minutes with occasional bed temperature differentials of 20°C occurring.

At 1106 hours, the bed defluidized again and the 1/2-inch-diameter solids feed tube plugged. The feed tube was removed and the bottom portion drilled to remove a hard crusty material. The vessel was allowed to cool down. Some bed underflow was removed and was noticed to be sticky. The material was lumps stuck together; however, as the material cooled, the lumps fell apart.

It was decided at this point that operation at 870°C was not possible, and the original test plan had to be altered. A new plan was devised which called for operation at 700°C without feeding fresh bed material and keeping the bed overflow closed. To find out at what temperature defluidization would occur, the bed temperature would be increased at 50°C intervals.

At 1155, the bed underflow previously removed was screened to break up any coarse agglomerates and added back into the vessel. At 1206 hours, red water feed was started with a well-fluidized bed held at 700°C. With operation at this lower temperature, CO levels were 160 ppm; at the higher temperature, CO levels had been less than 20 ppm. Operation at 700°C continued for 40 minutes before the bed temperature was raised to 750°C at 1245 hours. It was noticed that the bed bounce on the differential pressure gauge was becoming sluggish and the bed thermocouples were not responding to the increase in temperature. Addition of fresh bed material was started but with no limestone additions. By 1308, the bed temperatures were continuing to fall and mechanical stirring of the bed helped regained fluidization. The solids feeder was shut off at 1324 hours; the bed overflow was still closed, and the bed defluidized at 1325 hours. Red water was shut off, and 800 grams of agglomerated bed underflow were removed. Fresh alumina (900 grams) was added to replenish the bed.

Red water feeding continued from 1408 to 1427 hours at a bed temperature of 742°C. Operation was erratic with many CO and NO_x spikes in the offgas composition. It was felt that the precipitated salts in the red water might be responsible for some of the problems, and the feed solution was switched to a salt solution with no dinitrobenzoic acid at 1427 hours.

Operation continued until 1440 when bed temperature began to separate. The bed was mechanically stirred, bed underflow was removed (535 grams), and fresh bed (800 grams) was added. It was noticed that when the bed was stirred, CO_2 was released, indicating a dead area of the bed had been disturbed.

It was becoming obvious that operation at 750°C was not possible; however, in-bed feeding of fresh alumina with bed overflow withdraw was tried one more time at 750°C. The operation ran from 1504 to 1542 hours, but it was determined that the bed overflow pipe had plugged with agglomerated bed. At 1542, the bed defluidized and the system was shut down to remove the vessel lid and inspect the bed.

The bed appeared well fluidized on the top after it had cooled down, but near the bottom large white agglomerates one inch or so in size were blocking the bed underflow port. A total of 2052 grams of material were removed; 1619 grams were drained out but the remaining lumps had to be

dumped out through the lid. It was later learned by assay of this final bed sample that the sodium content was 1.5%.

A revised test plan was devised to test the zircon sand on the following day.

FEBRUARY 22, 1995 - TESTING A ZIRCON SAND BED

The plan to test the zircon sand called for operation at 650°C while feeding salt solution with no dinitrobenzoic acid for 90 minutes (Base Case 1), followed by operation at 650°C while feeding surrogate red water for 90 minutes (Base Case 2). If all went well, the bed temperature would be increased at 50°C increments until defluidization occurred. During all operations, continuous fresh bed would be fed to the vessel and bed overflow would be continuously withdrawn.

In the morning of February 22, the system was preheated and 3400 grams of zircon sand was added to the reactor vessel. When the bed temperatures reached 650°C, bed material feed at 51 gm and salt solution feed at 8.0 gm was started. No operational problems were encountered during the 90-minute Base Case 1 period. NO_x levels in the process offgas were 1840 ppm with low (6 ppm) CO levels and no CO_2. The bed overflow products contained some soft agglomerates about 1/16 inch to 1/8 inch diameter.

The feed solution was changed to surrogate red water at 0930 hours to start Base Case 2 testing. Again, no operational problems were encountered during the 90-minute period. The NO_x emissions in the process offgas remained virtually unchanged, averaging 1768 ppm. CO emissions averaged 464 ppm and CO_2 was 0.9%. Gray specks were visible in the agglomerated bed overflow products, probably unburnt carbon.

At 1102 hours the bed temperature was increased to 700°C, but no other conditions were changed. Once the temperature had stabilized, operation continued with no problems for 60 minutes. Bed overflow product still contained some gray specks, but the color was lighter. CO emissions averaged 407 ppm, and NO_x levels averaged 1773 ppm.

At 1215 hours, the bed temperature was increased to 750°C. Operation continued for 30 minutes at 750°C. CO emissions were less (258 ppm) than at the lower temperatures; however, the NO_x emissions were 2040 ppm.

At 1315 hours, the bed temperature was increased to 800°C. The surrogate red water solution contained a substantial amount of salt precipitate by this time and a fresh batch was started at 1320

hours. Operations continued until 1338 hours when the bed temperatures split apart and it appeared the bed had defluidized. Red water feeding was shut off, and the bed was mechanically stirred in an effort to regain fluidization. At 1400 hours, it was noticed that the bed overflow port was plugged, so the zircon feeder was shut off. It was discovered that the red water feed tube had also become plugged. Both plugged lines were cleared. By 1430 hours, the bed overflow was cleared and 3,029 grams of bed were recovered. The recovered material was very lumpy with some hard yellow agglomerates. The fluid-bed heater was turned off and the vessel lid removed to inspect the bed. Upon inspection, it was evident that the bed material had completely defluidized. Holes were visible in the frozen bed showing the locations of the feed tube, thermowell and pressure tap. As the bed cooled, refluidization occurred with the help of mechanical stirring, but some larger agglomerated chunks were visible floating around in the bed. The bed was drained out of the bed underflow port. A total of 5,175 grams of material was recovered.

With the information learned during the day's testing, it was decided to test the alumina bed material following the sample procedure used to test the zircon sand bed. The additional day of testing was authorized by Mr. Prakash Acharya on site and Mr. Bill Scoville of the IT Cincinnati office.

FEBRUARY 23, 1995 - TESTING AN ALUMINA BED

On February 23, 1995, the fluid-bed vessel was cleaned and preheated for operation. The alumina bed was added and allowed to heat to 650°C. The starting bed, 3,400 grams of blended 100- and 150-grit alumina, was added. At 0742 hours, fresh alumina bed material feeding was started at about 34 gm. Salt solution without dinitrobenzoic acid was started at 0751 hours at a rate of 8.7 gm. At 0800 hours the bed overflow port was plugged and had to be rodded out to clear the plug. This plug was caused by a zircon sand lump which had become lodged in the bed overflow pipe from the operation on the previous day, not a lump of alumina bed material. Operations ran smoothly throughout the 90-minute Base Case 1 test period. The NO_x concentration in the offgas averaged 1,746 ppm, and CO was about 6 ppm.

At 0930 hours, a fresh three-liter batch of surrogate red water was fed to the fluidized bed at a rate of 7.5 gm, and fresh bed material addition continued but was increased to a rate of 40 gm. The red water feed line plugged with precipitated salts on two occasions during the Base Case 2 period, resulting in nine minutes of feed outage. The CO and NO_x emissions were generally lower than measured on the previous day, possibly due to these feed outages. No noticeable carbon was visible in the bed overflow sample, as had been apparent on the Base Case 2 zircon sand bed overflow samples.

At 1104 hours the fluidized-bed temperature was increased from 650°C to 700°C and by 1130 hours conditions had stabilized to start Test 1. Surrogate red water was fed at a rate of 8.9 gm, and fresh bed material addition was maintained at about 42 gm. CO emissions averaged 350 ppm, while NO_x averaged 1,894 ppm. Occasional spikes of CO and NO_x were noticed at this higher temperature. It was also noticed that the agglomerates formed were larger than noticed while testing the zircon sand bed material. The cyclone collection rate was much greater, about 3 to 5 gm with the alumina bed material, than with the zircon sand bed which had a negligible collection rate. Toward the end of Test 1, the bed thermocouples split apart showing a possible fluidization problem beginning. Before the bed temperature was increased another 50°C, some bed underflow was withdrawn to check for large agglomerates in the bottom of the bed. The sample looked normal, and conditions were changed to establish conditions for Test 2 at 750°C.

At 1230 hours, the bed temperature was increased for a target of 750°C. By 1253 hours, conditions had stabilized to begin Test 2. CO emissions averaged 189 ppm while NO_x was 1,633 ppm. The red water feed line plugged on two occasions, with an outage of about six minutes during the period. At 1348 hours, the bed temperatures split, indicating defluidization had occurred. Red water feed was shut off at 1358 hours; within five minutes, the bed refluidized. The bed temperature was increased by 50°C to try to test 800°C operation during Test 3.

As soon as the red water was started, with a bed temperature of 770°C, the bed temperatures split. Red water feed was turned off and the bed allowed to cool in order to regain fluidization. Some (777 grams) bed underflow was drained and the bed temperature was increased to 800°C. By 1442 hours, the fluidized bed reached 800°C. Fresh bed feed and red water feed were started. The operation continued for about 15 minutes without problems. CO emissions averaged 25 ppm, while NO_x was 1,626 ppm. At 1507 hours, another temperature increase was made, resulting in almost immediate defluidization of the bed. The bed was allowed to cool and to regain fluidization. By 1523, the bed was fluidized and 2,343 grams of bed underflow was recovered. Upon inspection of the vessel interior, some large white lumps were still on the distribution plate, some lumps were in the shape of the tubes that were inside the vessel and had fallen off the tubes. A total of 383 grams of this white lumpy material was recovered.

ANALYTICAL RESULTS

BED OVERFLOW ANALYSES RESULTS

Bed overflow samples were selected to be representative of the test periods; i.e. Base Case 1 and 2, Test 1, 2, or 3 for each bed material. Samples from the first day of testing, February 21, 1995, were not included for the analysis. A sample was split out of the total 30-minute bed overflow sample for particle size distribution analysis. Another sample was split out and ground to an assay pulp for total sodium analysis. The results are presented in Table 7.

Particle size distribution results from the zircon sand bed overflow samples show an initial high degree of particle agglomeration, particularly evident from the amount of plus 70-mesh material during Base Case 1 at 0830 hours. By 0930, the bed overflow sample showed a steady-state condition of agglomeration which was maintained until Test 2 conditions of 750°C appeared to cause greater agglomeration of the bed material. Sodium content of the sample ranged for 0.2% in the 0830 hours Base Case 1 sample to 0.5% in the last Test 2 sample.

Particle size distribution results from the alumina bed overflow samples showed a constantly increasing degree of agglomeration throughout the day of testing. The alumina bed did not show the initial high degree of agglomeration during Base Case 1 that was observed during testing of the zircon sand. The sodium content of the bed overflow samples ranged from 0.2% to 0.6%.

FINAL BED MINERALOGY

Microprobe Analysis of Caked Material from Fluid-bed Roaster Test

Electron microprobe analysis provides a means of chemically analyzing particles as small as one micron. A beam of electrons emitted from a heated tungsten filament is focused and accelerated to a potential of 15 keV (typically) under a vacuum and either rastered across a sample to produce an image, or aimed at a particular spot to get an analysis. The electrons can undergo a variety of reactions in the sample, but the two of interest in microprobe analysis are backscattering and the production of x-rays.

Table 7. Summary of Bench-scale Fluidized-bed Testing
Bed Product Analysis

Zircon Sand Bed
Direct Percent at Stated Size, %

Size US Mesh Pass	Retain	Starting Bed	Base Case 1 0830 BOF	Base Case 1 0930 BOF	Base Case 2 1000 BOF	Base Case 2 1100 BOF	Test 1 1130 BOF	Test 1 1215 BOF	Test 2 1300 BOF	Test 2 1315 BOF	Final Bed	Final Cyclone
-	12		0.4	0.4	0.7	0.9	0.6	0.7	0.5	0.5	2.4	
12	20		2.4	3.0	2.4	1.4	1.0	1.1	1.5	0.8	0.6	
20	40		2.5	2.9	1.9	0.3	0.2	0.1	0.4	0.3	0.5	0.4
40	70	0.3	45.3	4.7	3.9	2.1	2.0	2.7	7.4	10.7	2.8	0.6
70	100	11.0	29.8	15.9	15.9	14.3	13.9	14.7	18.9	19.7	13.8	5.5
100	200	88.0	19.7	72.9	74.8	80.5	81.7	80.1	70.9	67.6	79.2	81.3
200	pan	0.8	0.0	0.3	0.4	0.6	0.6	0.5	0.4	0.4	0.8	12.3
TOTAL		100.0	100.0	100.0	100.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Cumulative % > 70 Mesh, %		0.3	50.5	10.9	8.9	4.6	3.8	4.6	9.8	12.3	6.2	0.9
Sodium Content %		0.0	0.175	0.341	0.369	0.415	0.404	0.389	0.461	0.499	0.278	0.975

Alumina Bed
Direct Percent at Stated Size, %

Size US Mesh Pass	Retain	Starting Bed	Base Case 1 0830 BOF	Base Case 1 0930 BOF	Base Case 2 1000 BOF	Base Case 2 1100 BOF	Test 1 1200 BOF	Test 1 1230 BOF	Test 2 1300 BOF	Test 2 1400 BOF	Test 3 1500 BOF	Final Bed	Final Cyclone
-	12		1.0	4.1	3.5	1.5	1.6	1.2	1.2	0.8	1.9	2.2	
12	20		1.0	1.9	1.7	1.6	1.0	1.1	1.1	1.1	2.2	1.6	
20	40		0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.7	1.2	0.8	
40	70	0.1	1.1	1.8	1.6	2.0	3.1	3.7	3.3	5.4	6.0	4.2	0.0
70	100	34.5	37.6	41.6	42.8	44.6	46.1	48.1	44.5	42.8	41.6	42.4	1.2
100	200	60.6	56.2	48.1	48.2	48.1	46.2	43.7	47.2	46.5	44.9	46.3	86.4
200	pan	4.7	2.7	2.0	1.9	2.0	1.8	1.9	2.4	2.7	2.2	2.5	12.4
TOTAL		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Cumulative % > 70 Mesh, %		0.1	3.6	8.4	7.1	5.4	5.9	6.3	5.9	8.0	11.3	8.8	0.0
Sodium Content %		0.0	0.170	0.450	0.476	0.493	0.513	0.550	0.444	0.373	0.307	0.273	0.129

BOF = Bed Overflow

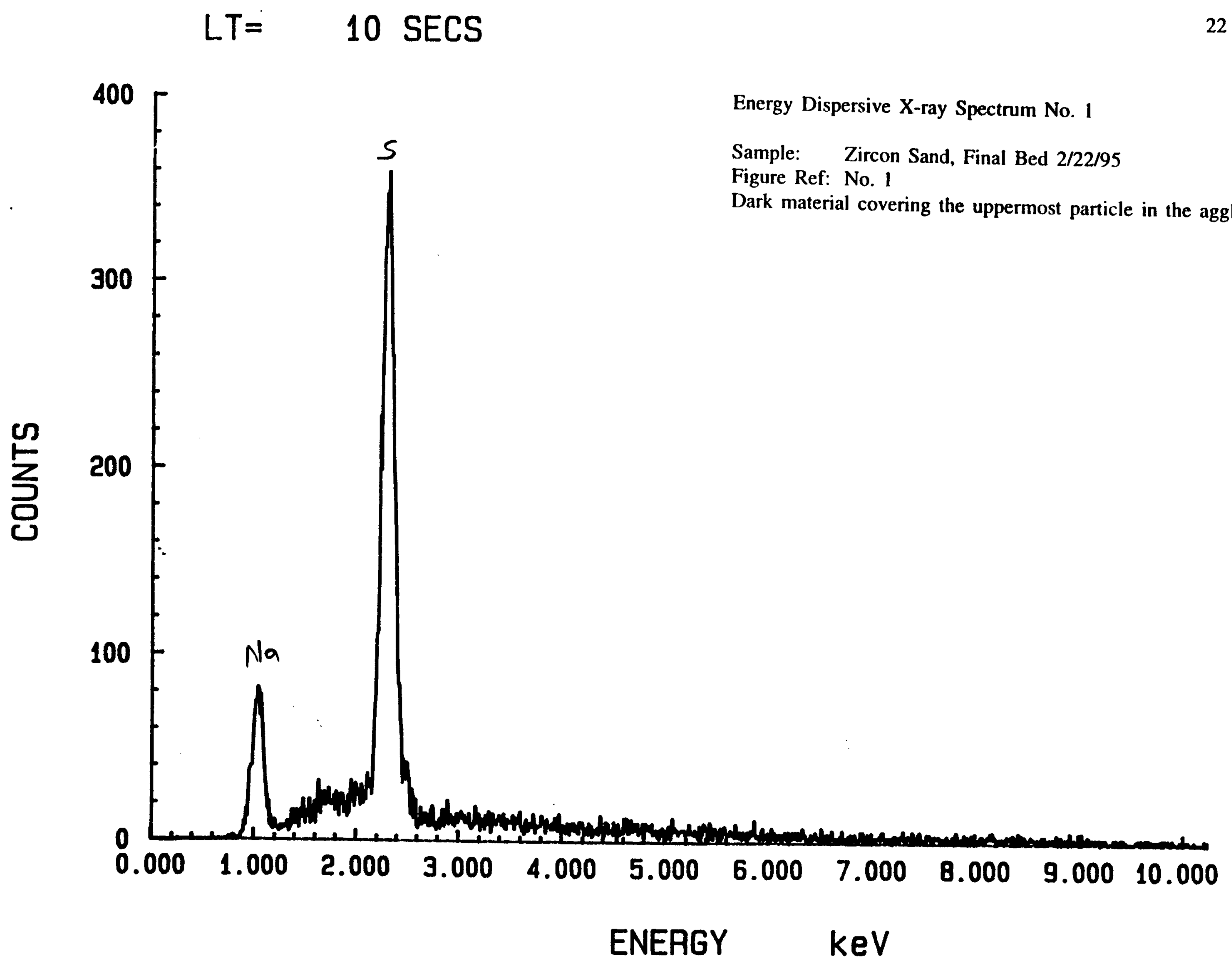
Electron backscattering results from electronic interaction with the positive charge of the nuclei of the atoms in the sample which deflects the path of the electrons at various angles. After successive interactions, the electrons can re-emerge from the sample and be detected with an electron detector. Since each nucleus of an element with high atomic weight has a higher positive charge than the nuclei of lighter elements, elements with high atomic weight produce more backscattering and produce relatively bright areas in a backscattered electron image. These images are often good indicators of differences in chemical composition. The photos of the sodium sulfate on the zircon particles demonstrate this effect.

The production of x-rays results when the beam electrons knock out inner-shell electrons from atoms within the sample, followed by an outer-shell electron replacing the ejected electron. The replacement process emits an x-ray with an energy that is characteristic of the element present, providing a means of chemical analysis. An x-ray spectrum shows the energies of the x-rays, so the elements can be identified. The spectra shown were obtained with an energy-dispersive detector which is capable of analyzing elements down to sodium in the periodic table. Oxygen in the sodium sulfate was detected with a wavelength-dispersive spectrometer, which can detect lighter elements.

The following photographs show to what extent the particles in the final bed sample had become glued together with sodium sulfate salt.

Figure 1. Microprobe Analysis
Sample: Zircon Sand, Final Bed 2/22/95

The white particles are zircon. The dark material holding the agglomerated zircon particles together is sodium sulfate. The dark spots on the particle at the lower right are also sodium sulfate. Spectrum No. 1 (see following page) was obtained from a spot on the dark material covering the uppermost zircon particle in the agglomeration.



Energy Dispersive X-ray Spectrum No. 1

Sample: Zircon Sand, Final Bed 2/22/95
Figure Ref: No. 1
Dark material covering the uppermost particle in the agglomeration.

Figure 2. Microprobe Analysis
Sample: Zircon Sand, Final Bed 2/22/95

A closeup of a zircon particle with attached particles of sodium sulfate.

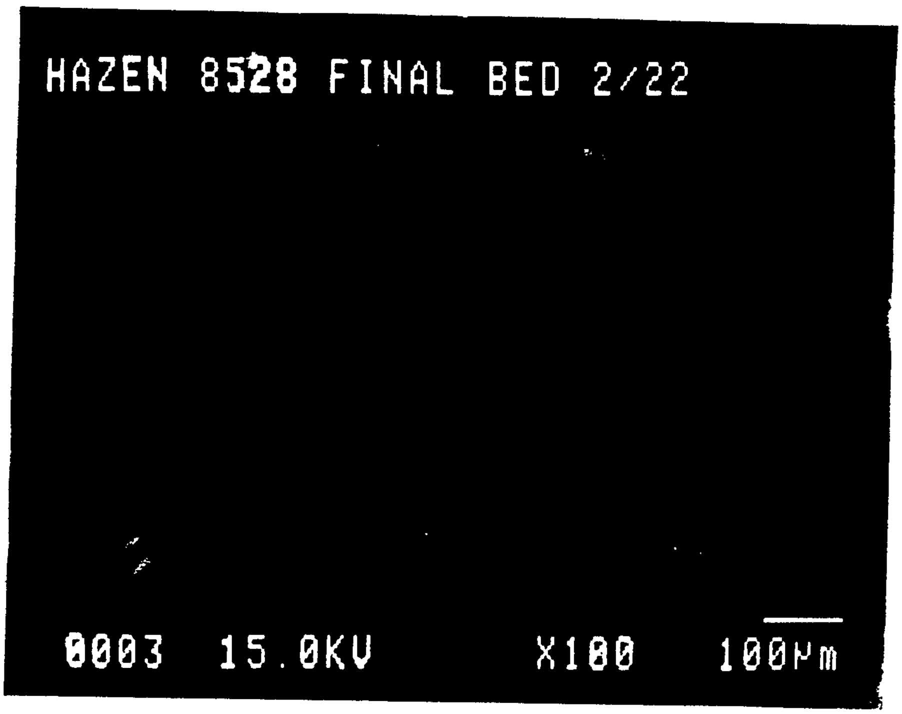


Figure 3. Microprobe Analysis
Sample: Zircon Sand, Final Bed 2/22/95

Zircon particles with various degrees of sodium sulfate coatings.

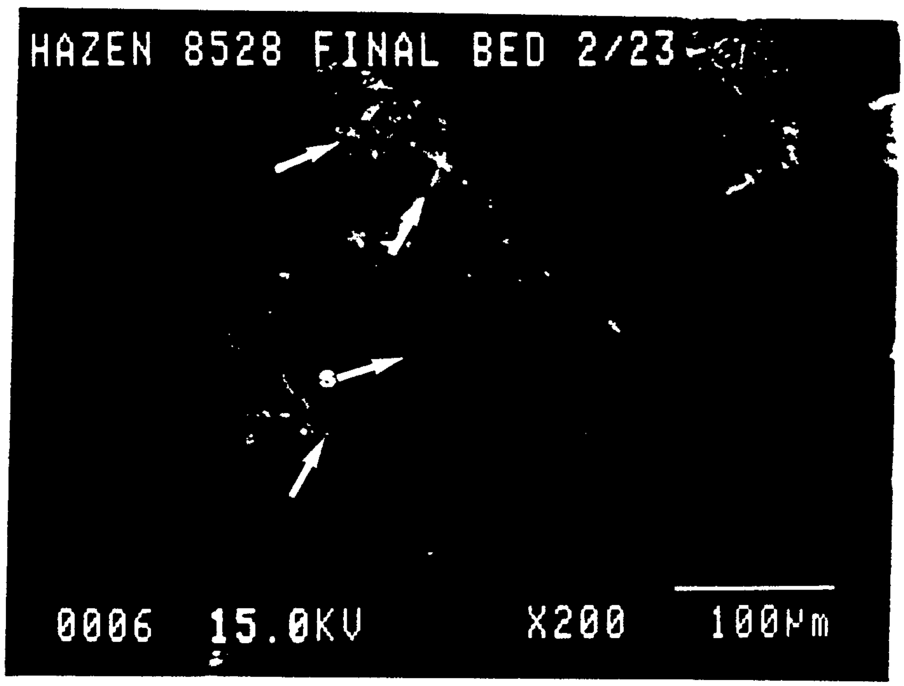


Figure 4. Microprobe Analysis
Sample: Brown Alumina, Final Bed 2/23/95

Area a: Alumina particles.

Area s: Sodium sulfate cementing the alumina particles together. A closeup of this area is shown in Figure 5.

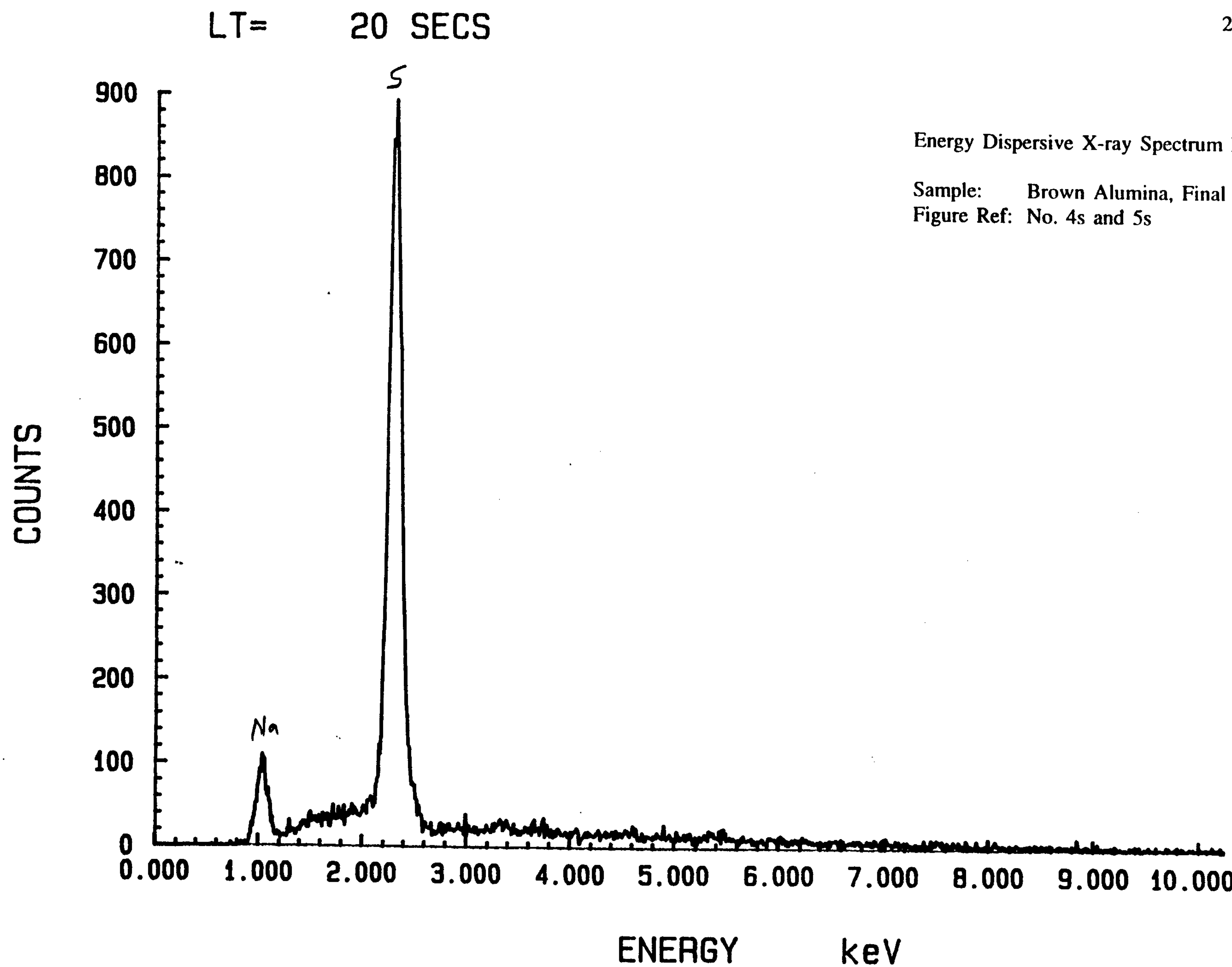
These areas are also sodium sulfate.

Figure 5. Microprobe Analysis
Sample: Brown Alumina, Final Bed 2/23/95

Area a: Alumina.

Area s: The fractured areas are sodium sulfate (see Spectrum No. 2).

The small, relatively white spots are titanium oxide.



Energy Dispersive X-ray Spectrum No. 2

Sample: Brown Alumina, Final Bed 2/23/95
Figure Ref: No. 4s and 5s

Hazen Research Inc

APPENDIX A

Fluid-bed Test Facility
Exhaust Gas Analyzers

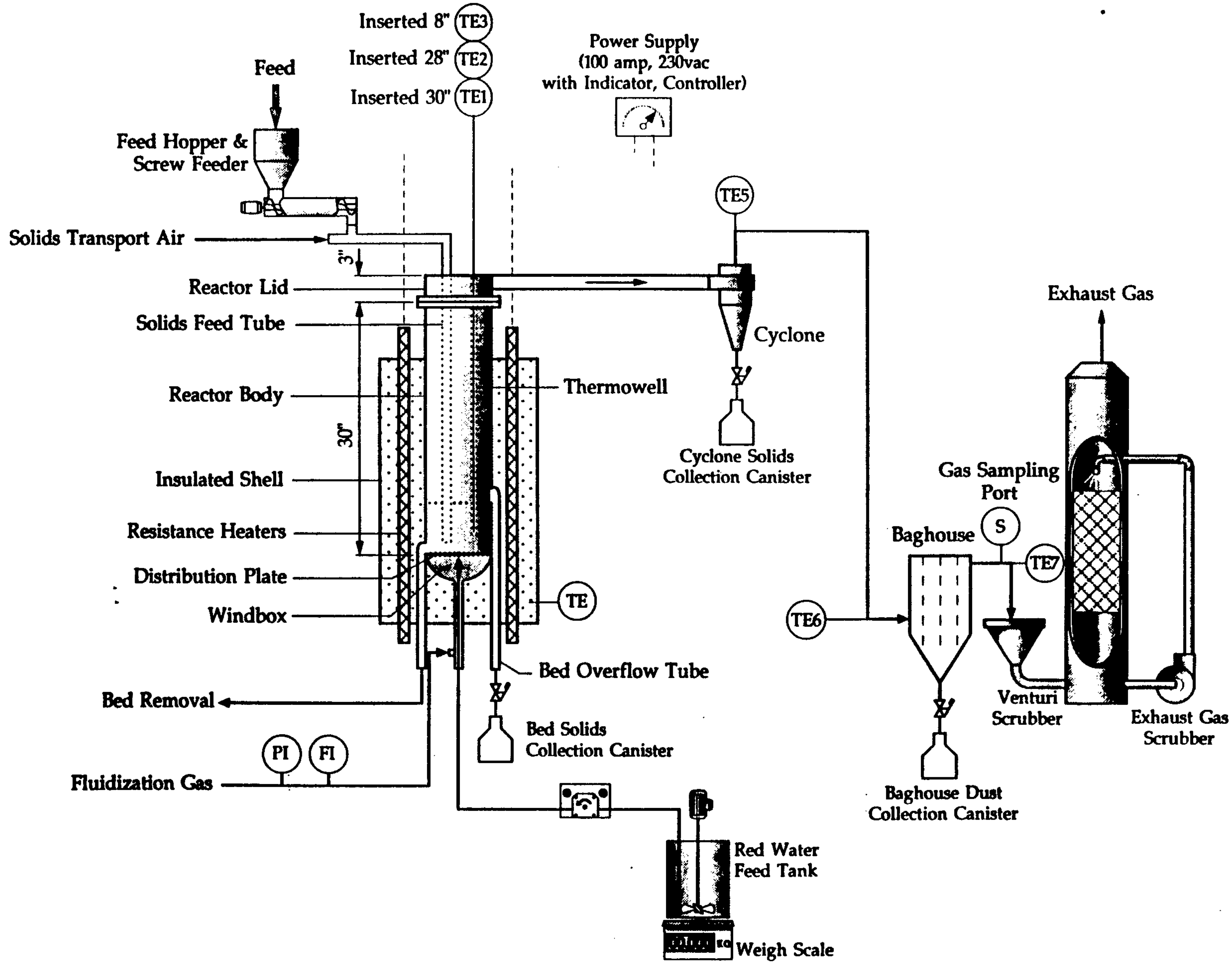


Figure . 4-inch Fluid Bed Reactor System

Hazen Research Inc

CONTINUOUS EMISSIONS MONITORS
CEM

Oxygen:	Infrared Industries Model 2000	Range	0 to 1% 0 to 10 % 0 to 25%
Carbon Dioxide:	Infrared Industries	Range	0 to 20% 0 to 100%
Carbon Monoxide:	Beckman Model 864	Range Range	0 to 500 ppm 0 to 5,000 ppm
Sulfur Dioxide:	Thermo Electron Pulsed Fluorescence Model 40	Range	0 to 50 ppm 0 to 100 ppm 0 to 500 ppm 0 to 1,000 ppm 0 to 5,000 ppm
Nitrogen Oxides:	Beckman Model 951A	Range	0 to 10 ppm 0 to 25 ppm 0 to 100 ppm 0 to 250 ppm 0 to 1,000 ppm 0 to 2,500 ppm 0 to 10,000 ppm
Total Hydrocarbon:	Thermo Environmental	Range	0 to 100 ppm 0 to 1,000 ppm 0 to 10,000 ppm

APPENDIX B

Logbook Entries
Operational Data Sheets
Temperature and Offgas Emissions Data Printouts
Temperature and Offgas Emission Profiles
CEM Calibration Log

Test No.
Project No. 8528
Date 2-21-95

4-INCH FLUIDIZED BED COMBUSTOR
Data Sheet

Time	TEMPERATURES Lower Bed T-1	Upper Bed T-2	Free-board T-3	Free-board T-4	outlet Cy-clone T-5	inlet Bag-house T-6	Bed outlet ~~Gas Prht.~~ T-7	PRESSURES Press. FRB	Bed D.P. "H2O	Cyc. D.P "H2O	Bgh. Press. "H2O	FEED GAS Air scfm	Air to liquid ~~N2~~ scfm	AIR Feed ~~N2~~ scfm	SSV ft/sec
0906	889	889	695	-	374	235	42	2	2.8	0	2.5	1.17	0.1	0.38	1.55
0930	871	882	705	-	408	251	43	3.0	2.6	0	3.0	1.46	0.1	0.38	1.67
1000															
1030	913	917	727	-	429	213	43	3.5	3.6	0.5	4.5	1.46	0.1	0.38	1.89
1100	907	909	742	-	461	254	49	4	3.5	0.5	5	1.46	0.1	0.38	1.88
1215	693	693	649	-	355	244	49	3.5	3.5	0.5	4.5	1.46	0.1	0.38	1.54
1230	689	689	652	-	360	255	48	4.0	3.3	0.5	5.0	1.46	0.1	0.38	1.53
1245	688	688	659	-	382	261	49		2.8						
1300	701	715	684	shell 740	400	272	50	4.0	2.8	0.5	5.5	1.74	0.1	0.38	1.76
1315	750	750	676	shell 740	391	270	49	4.0	3.3	0.5	5.5	1.74	0.1	0.38	1.84
1345	767	767	682		391	268	49	3.5	3.8	0.5	5.0	1.74	0.1	0.38	1.86
1401	741	739	692		406	216	50	4.5	3.8	0.5	6.0	1.74	0.1	0.38	1.82

Comments:

4-INCH FLUIDIZED BED COMBUSTOR
Data Sheet

Test No. 8528
Project No.
Date 2-21-95

	FEED		SOLID PRODUCTS						OFF-GAS ANALYSIS						
Time	Addition g	Rate g/min	Bed O'F g	Bed Dump	Cyclone g		Baghouse g		O2 %	CO2 %	CO ppm	SO2 ppm	HC ppm	NOx ppm	Time
0855	985	32.8							20.4	0	0.7	29	1.1	30	(0900)
0925	⅃ 1000	-	(0930) 234		(0930) 168				20.1	0.4	0.7	5.5	3.0	1150	(0930)
1017	⅃ 1000	32.2	(1000) 179	(1000) 394					19.8	1.9	0.8	2	4	1437↑	(1030)
1048	⅃ 1000		(1034) 169		(1035) 381				20.1	1.4	0	0.9	3	619	(1100)
			(1100) 436.7		(1100) 246										
			(1245) 326						19.9	0.8	145	2.6	2	1784	(1215)
1252	313								19.7	1.1	165	2.5	2	1614	(1230)
1310	OFF								20.0	0.7	153	2.6	2	1776	(1245)
			-		(1300) 209				20.1	0.9	107	2.4	1.1	1488	1300
1330	(port) 900			BUF 792					20.2	0.5	28	2.2	1.9	1421	1315
									20.0	0.2	37	0.77	1.1	900	(1330)
									19.9	1.0	231	2.4	1.1	1360	(1407)

Comments:

⅃ 900g Alumina + 100g limestone

Test No.
Project No. 8528
Date 2-21-95

4-INCH FLUIDIZED BED COMBUSTOR
Data Sheet

	TEMPERATURES					Inlet	Outlet	PRESSURES				FEED GAS			
	Lower Bed	Upper Bed	Free-board	~~Free-board~~	Cy-clone	Bag-house	Gas Prht.	Press.	Bed D.P.	Cyc. D.P	Bgh. Press.	Air	Air to Liquid ~~N2~~	A Feed L R ~~N2~~	SSV
Time	T-1	T-2	T-3	~~T-4~~ Shell	T-5	T-6	T-7	FB	"H2O	"H2O	"H2O	scfm	scfm	scfm	ft/sec
1435	712	738	693	740	410	282	50	4.5	3.4	0.5	6.5	174	0.1	0.38	1.73
1506	729	730	664		381	266	50	4.5	4.5	0.5	6	168	0.1	0.38	1.75
1530	734	740	668		381	271	50	4.5	7.0	0.5	6	168	0.1	0.38	1.75

Comments:

Test No.
Project No. 8528
Date 2-21-95

4-INCH FLUIDIZED BED COMBUSTOR
Data Sheet

	FEED		SOLID PRODUCTS						OFF-GAS ANALYSIS						
	Addition	Rate	Bed O'F		Cyclone		Baghouse		O2	CO2	CO	SO2	HC	NOx	
Time	g	g/min	g		g		g		%	%	ppm	ppm	ppm	ppm	
1504	1700				(1500) 357				20.6	0	1.3	0.4	1.1	211	(1435)
1515	–		358						20.6	0.15	4.3	1.2	1.1	567	(1500)
1530	–		502						20.6	0	3.8	2.0	0.1	1242	(1530)
1545	–		660												
1555	OFF	33.3			227.4										

Comments:

Gas Analysis

Instrumentation Calibration Log

Project # 8502

Calibration	Date	Time	Gas 1/	O2 %	CO2 %	CO ppm	SO2 ppm	NOx ppm	THC ppm	Comments
			SPAN =	4.78	14.9	291	219	1040	1011	
Check	1-17-95									
Adjust.										
Check	2-21-95	0800		4.8	14.6	270	180	650	1080	
Adjust.	—	—		NO	14.9	290	180	1040	1011	
Check										
Adjust.										
Check										
Adjust.										
Check										
Adjust.										
Check										
Adjust.										
Check										
Adjust.										
Check										
Adjust.										
1/ Calibration Gas:			Air							
			Gas A							
			Gas B							
			Gas C							

Test No.
Project No. 8528
Date 2-22-95

4-INCH FLUIDIZED BED COMBUSTOR
Data Sheet

	TEMPERATURES							PRESSURES				FEED GAS			
Time	Lower Bed T-1	Upper Bed T-2	Free-board T-3	~~Free-board~~ wall ~~T-4~~ Shell	Cy-clone T-5	Bag-in house T-6	Bag out ~~Gas Prht.~~ T-7	FB Press.	Bed D.P. "H2O	Cyc. D.P "H2O	Bgh. Press. "H2O	Air scfm	Purge salt soln ~~N2~~ scfm	A i r Feed ~~N2~~ scfm	SSV ft/sec
0800	631	632	631	.	285	203	37	4	5.8	0.5	4	1.4	0.1	0.4	1.42
0830	651	651	652	..	314	228	39	3	5.8	0.5	4	1.4	0.1	0.4	1.46
0900	656	655	646	680	320	238	42	4	10	0.5	4	1.4	0.1	0.4	1.46
0930	639	641	648	680	339	247	47	4.5	7.4	0.5	6.5	1.5	0.1	0.4	1.44
1000	649	652	654	680	346	254	46	4	7.0	0.5	6.0	1.5	0.1	0.4	1.52
1030	650	650	655	680	343	255	47	4.5	6.4	0.5	6.5	1.6	0.1	0.4	1.58
1100	651	653	655	680	342	255	47	4.5	6.4	0.5	6.0	1.6	0.1	0.4	1.58
1130	694	694	680	720	353	259	48	4.5	6.4	0.5	6.0	1.6	0.1	0.4	1.65
1200	690	692	684	720	361	262	48	4.5	6.4	0.5	6.0	1.6	0.1	0.4	1.64
1215	688	690	691	720	362	263	47	4.5	6.4	0.5	6.0	1.6	0.1	0.4	1.64
1230	710	710	726	780	370	267	48	4.5	+10 ↓	0.5	6.0	1.6	0.1	0.4	1.69
1300	747	747	750	820	384	271	48	4.5	+10	0.5	7.0	1.6	0.1	0.4	1.76
1315	739	740	746	820	380	210	48	4.5	+10	0.5	7.0	1.6	0.1	0.4	1.74
1330	715	715	772	860	381	273	48	4.5	+10	0.5	7.0	1.6	0.1	0.4	1.70
1400	735	737	707	800	343	257	47	2	+10	0.5	2	1.6	0.1	0.4	1.74

650°C Salt soln w. Zircon sand
650°C Zircon
700°C Red Water w
750°
800°C

Comments:
↓ Bed ΔP line plugging

Test No.
Project No. 8528
Date 2-22-95

4-INCH FLUIDIZED BED COMBUSTOR
Data Sheet

	FEED		SOLID PRODUCTS						OFF-GAS ANALYSIS						
Time	Addition g	Rate g/min	Bed O'F g		Cyclone g		Baghouse g		O2 %	CO2 %	CO	SO2	HC ppm	NOx ppm	
0754	1200	75							20.5	0	8.3	2.6	0	1608	(0800)
0810	1200	54.5	1117						20.5	0.02	4.3	2.8	0.09	1797	(0830)
0832	1200	54.5	(0830) 1055		(0830) 5										—
0854	1200	41.3	(0900) 638		(0900) 0				20.5	0.01	3.5	2.8	0	1914	0900
0923	1500	53.6	(0930) 2104						20.5	0.01	2.6	2.4	0	1670	0930
0951	1500	51.7	(1000) 1641						19.7	1.1	607	3.1	4	1709	1000
1020	1500	55.6	(1030) 1556		(1030) .21				19.7	1.1	472	2.5	5	1833	1030
1047	1500	51.7	(1100) 1603						19.8	0.9	412	2.8	5.9	1801	1100
1116	1500	51.7	(1130) 873						[illegible]	[illegible]	311	2.8	0.1	1981	(1130)
1145	1500	48.4	(1200) 2171		(1200) 26.9				19.8	0.9	359	2.7	0.1	1714	(1200)
1217	1500	55.6	(1215) 800						19.8	0.9	353	2.9	0.1	1789	(1215)
1244	1500	57.7	(1230) 591						19.7	0.9	218	2.8	0.1	1748	(1230)
1310	1500	51.7	(1300) 964						19.7	0.9	204	3.1	0.1	2024	(1300)
1339	1500	71.4	(1315) 496						19.6	1.12	250	3.2	0.1	2019	(1315)
1400	1500	46							19.9	0.6	200	3.0	0.1	1909	(1330)
1432	OFF	.	(1430) 3029	(Bed) 5175	Final 110				20.5	0	8.7	0.5	0.09	192	(1400)

Comments:

Test No.
Project No. 8528
Date 2-23-95

4-INCH FLUIDIZED BED COMBUSTOR
Data Sheet

		TEMPERATURES							PRESSURES				FEED GAS			
	Time	Lower Bed T-1	Upper Bed T-2	Free-board T-3	~~Free-board~~ Shell ~~T-4~~	Cy-clone T-5	Bag-house T-6	~~Gas Exit~~ Bth Out T-7	Press. FB	Bed D.P. "H2O	Cyc. D.P "H2O	Bgh. Press. "H2O	Air scfm	Salt soln scfm	A I R Feed scfm	SSV ft/sec
Salt soln	0800	644	644	598	650	319	227	38	4.5	6.5	0.5	6	1.5	0.1	0.4	1.51
	0830	646	647	642	670	338	247	40	5.0	5.5	0.5	6	1.5	0.1	0.4	1.52
	0900	648	648	629	660	343	254	42	5.5	5.8	0.5	6	1.5	0.1	0.4	1.52
	0930	644	644	651	675	358	260	44	5.5	5.5	0.5	7	1.5	0.1	0.4	1.51
Red Water	1000	644	645	640	670	359	262	44	5.5	5.4	0.5	7	1.5	0.1	0.4	1.47
	1030	651	651	632	670	354	260	46	5.5	5.4	0.5	7	1.5	0.1	0.4	1.47
	1100	653	653	634	670	347	260	48	5.5	6.0	0.5	7	1.5	0.1	0.4	1.48
RW @ 700°C	1130	697	697	658	720	349	257	50	5.0	5.5	0.5	7	1.5	0.1	0.4	1.52
	1200	701	702	668	720	352	260	50	5.0	5.5	0.5	7	1.5	0.1	0.4	1.61
	1230	692	696	657	720	355	261	50	5.0	5.5	0.5	7	1.5	0.1	0.4	1.60
	1300	744	745	687	760	365	260	49	5.0	5.5	0.5	7	1.5	0.1	0.4	1.64
	1330	747	747	707	750	382	267	49	5.5	5.8	0.5	7	1.5	0.1	0.4	1.64
	1400	695	756	713	750	376	266	49	5.5	5.8	0.5	7	1.5	0.1	0.4	1.60
	1430	717	717	699	720	369	260	49	5.5	3.0	0.5	7	1.5	0.1	0.4	1.60
	1500	802	804	767	815	407	274	49	5	4.0	0.5	7	1.5	0.1	0.4	1.74

Comments:

Test No.
Project No. 8528
Date 2-23-95

4-INCH FLUIDIZED BED COMBUSTOR
Data Sheet

	FEED		SOLID PRODUCTS						OFF-GAS ANALYSIS						
Time	Addition g	Rate g/min	Bed O'F g	Bed U'F	Cyclone g		Baghouse g		O2 %	CO2 %	CO ppm	SO2 ppm	HC ppm	NOx ppm	
0742	1500	50			(0800) 249.4				20.5	0	6.7	1.8	0	1313	(0800)
0812	1500	34	(0810) 2167						20.5	0	5.9	2.5	0	1825	(0830)
0856	1500	38	(0830) 577		(0830) 84.8				20.5	0	5.1	2.4	0	1856	(0900)
0935	2000	37	(0900) 722		(0900) 90				20.5	0	5.1	2.4	0	1737	(0930)
1029	2000	42	(0930) 1436						19.9	0.7	318	2	0	1623	(1000)
1117	2000	42	(1000) 935		(1000) 186.8				20.1	0.6	171	2	0	1320	(1030)
1206	2000	42.6	(1030) 764						20.0	0.8	246	2.3	0	1799	(1100)
1253	2000	44.4	(1100) 962		(1100) 233				19.6	1.2	284	1.8	0	1554	(1130)
1338	2000	42.6	(1130) 929						19.6	1.12	304	2.3	0	1943	(1200)
1425	OFF	–	(1200) 945		(1200) 256				19.7	1.01	367	2.2	0	1860	(1230)
1444	1000	47.6	(1230) 1110	(1230) BUF 829					19.8	0.9	188	2.2	0	1473	(1300)
1505	1294		(1300) 449		(1300) 219				19.8	0.9	201	1.9	0	1875	(1330)
1529	OFF		(1330) 1440						20 ⊥	0.25	32	1.0	0	799	(1400)
			(1400) 1742		(1400) 295.5				20.6 ⊥	0.03	4	1.0	0	267	(1430)
			(1430) 785	(1430) BUF 777					20.1	0.8	22	2.3	0	1808	(1500)
			(1500) 244												
Comments: ⊥ Bed water OFF			(1525) 484g		Final 420.7										

.08

Project 8528 SOW 2/15/95 Attending

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IT Corp

Bench Scale Testing

To Study Fluidize bed agglomeration Tendencies while incinerating a Surrogate Red Water

Surrogate Composition

	15%	30%
Water	85	70
3,5-Dinitrobenzoic Acid	7.8	15.7
Sodium Sulfite	2.6	5.1
Sodium Sulfate	2.6	5.1
Sodium Nitrite	1.8	3.6
Sodium Nitrate	0.2	0.5

When mixed solution turns bright red than changes to pink then to yellow with gas release, precipitate forms

Neutralize Dinitrobenzoic acid with NaOH before adding to salt solution prevents gas release and most precipitate formation

8528 2/21/95

SDW

Reactor Set-up

Bed Dp tap	28 1/4"	:	1.75" up from plate
Feed tube	26 1/4"	:	3.75" " "
Thermowell	29 1/4"	:	0.75" " "

Flange to plate : 30"

95.5g/50ml 1.91 g/cc 90+150 Alumina 119.2 lb/cf

.074 cf of volume - 8.85 lbs 4000 g

@ 1 SSV ft/sec 5.94 ACFM P 4.68 1.26 SCFM
2 11.88 ACFM 2.54 SCFM

0745 Added 4000 g to reactor which is a 1:1 mix of Alumina 90 & 150

0851 Removed BOF 2188.0
cyc 112.7

Bed ΔP 2.0" H_2O

0855 Added 985 Al_2O_3 to feeder.
Feed on

0911 Liquid feed on (Red water at 15% solids)

0915 Nox has increase to 1800 ppm. (off range)
Note: Changed range at instrument to 0 - 10,000 ppm.

0917 Increasing feed rate of Red Water until Bed temps are effected.

0923 Nox back to 1000 ppm range. It reads the same whether 1000 or 10000 ppm range.

2/21/95 8528 SOW

0925 Add 900g Alumina +100g limestone

0931 Have fed 127g red water in 41min, 186g/hr

0936 Initially when feeding in Alumina/limestone mixture NOx dropped to ~ 1000 ppm but has currently increased to ~ 2200 ppm. All other gases were also effected ie, O_2 decreased CO_2 increased.

0950 First BOF had some aggomerates
Increase feedrate. was ~ 381 mls/hr, target is ~ 1000 mls/hr.

0955 Increase solids feedrate from 50 → 75% at controller.

0959 Bed ΔP has gone dead. (defluidized)

1000 Feed off (red water) & solids feeder.
Removed 394g from bed dump.
179g BDF

1009 Solids feeder back on.
Tried to rod bed area. solids feel sticky. ΔP 0.2" H_2O & dead at magnehelic.

1019 Tapping on bottom of reactor seems to regain fluidization, still feeding in Al_2O_3/limestone only.

1026 Red water feed back on. (383g fed thus far)

1028 Nox increasing, fluidization looks ok!

1031 Bed temps, °C 852°C, 924°C, Mag bouncing

1038 Bed temps 895°C, 900°C

1041 Still observing spikes in gas composition.

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1047 Ocassionally bed temps will split with T_1 about 20°C cooler than T_2.

1048 Add 900 Al_2O_3 100 $CaCO_4$

1101 680g fed total of Red Water $\frac{297\text{g fed since 1026}}{35\text{ min}}$ = 509 g/hr

1106 ΔP gone dead, temps split, 685° & 886°C Red water off

1108 Solids feeder plugged.

1131 Pulled out feed tube & had to drill out to clear. Re-installed. Bed is still dead & will not re-fluidize.

1?4 Removed some bed from bed dump. Soft lumps have formed.

Heat off to reactor

1149 Note: Have decided to operate at a lower temperature of ~ 1300°F. (700°C). It may be ash is melting in bed causing defluidization

1155 Add 788 g of old bed back to reactor. Bed is a little low ~ ΔP ~ 2", now 4.8" H_2O

1206 Fed 742g red water thus far. Have regained fluidization since decreasing temps. from 1600°F to 1300°F.

Red Water feed on.

1207 NOx increasing, shell temp & Beds ≈700°C. No Al_2O_3/Limestone being fed in right now, Just red water
Shut BOF OFF

1232 Red water 974g fed

1245 Increasing temp to 750°C, no problems @ 700°C Good fluidization while feeding red water @ 0.5ℓ/hr.
1086 kg red water fed

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1249 Bed ΔP appears to be getting sluggish at a ΔP of 2.8" H_2O.

Adding 313g bed back into reactor via feeder. Tapping reactor bottom helps regain fluidization.

1302 Bed temps have not responded much since increase.
T1 701°
T2 715° Although bed is being added in. + RW.

1308 Shut feed off. (Red water) Temps continue to decrease. Stirring bed with rod.

1312 Stirring helped. T's to 750°C. Red water back on. 1.290 kg RW Fed

1324 Solids feeder off. ΔP 3.4" H_2O & bouncing.

1325 Bed temps have split. 705 & 742°C.
R.W. OFF.
Taking some BUF out of reactor. (792g removed) / Noticed agglomerates) BB's

1331 Added 900g Al_2O_3 to reactor via sideport. ΔP up to 5.8" H_2O.

1338 Red Water back on 1.393 kg RW Fed
Beds 767°C

1357 Red water not going in. Feed line out of pump had salts in it.

1400 Red water going in now.

1427 Start feeding sol'n of just sodium salts. without DiNitroBenzoic Acid.

1440 Bed temps are starting to split., Stir bed area.
Taking some BUF out, 535 g
Added fresh Al_2O_3 to reactor 800 g

Decreasing temp to 1300°F.

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Note: When stirring bed. CO_2 is released, This is a area that was dead, then burned when stirred.

1456 Increase temp back to 750°C & will try feeding in Al_2O_3 while feeding salt sol'n. Salt sol'n off

1504 Salt sol'n on. Al_2O_3 feeder on. Bed temps 750°C.

1533 BOF was plugged ΔP from 7.0" $H_2O \rightarrow$ 5.8" H_2O after unplugging. Temps 688° & 728°C.

Decreasing temperature to 700°C.

1539 Fed 418g since 1427 hrs : 348 cc/hr

1542 Bed temps 608° & 669°C.
Stir bed

1546 Salts sol'n feed off. Stiring bed area did not regain fluidization. E1 566°
E2 654°

1555 Al_2O_3 feed in; shut off ; Salt sol'n also off.

1626 Removed reactor lid. Mat'l on top is loose but towards bottom near plate there are white chunks of mat'l.

Recover 2052 g from bed, were able to drain 1619 g remaining would not drain had to dump by removing reactor. large hard white lumps were preventing drainage.

2-22-95 SAW B528

0640 Start Preheating system.

0706 Loading 3400g Zircon Sand to reactor.
Will heat bed to 650°C 2.645g/cc, 165.1 lb/cf

0730 Load 1200g in dry Feeder,

0750 Start salt solution @ 534 g

0751 Start Solids Feeder 80%

0800 Feed salt solution @ 614 = 480 g/hr

0830 Salt Sol'n ⟶ @ 824 = 420 g/hr

0900 Salt Sol'n ⟶ @ 1.079 = 510 g/hr

Note: Have been feeding salt sol'n (~500g/hr) and zircon sand (~55g/min) for 70 minutes with no problems. Bed temps at ~650°C with BOF. (Noticed some agglomeration)

0930 Salt Sol'n ⟶ @ 1.334 = 510 g/hr
Switch to Red Water Surrogate Feed, temp 650°C

1000 Red Water 233g in 30min. = 466g/hr
Zircon Sand Rate ~55 g/min 3300 g/hr

1030 Red Water @ 500g = 534g/hr

1100 Note: Been feeding Red Water soln (~500g/hr) & Zircon Sand (3300g/hr) maintaining Bed temps of 650°C for ~190min with no problems ie. defluidization. NO_x has basically remain the same at ~1700-1800 ppm. O_2 has decreased to ~19.5% while CO & CO_2 have increased, Noticed unburn't carbon in BOF.

Red Water @ 777g = 554g/hr

2-22-95 SDW. 8528

1102 Change Conditions
Increasing temperature to 700°C while everything else will remain the same i.e. feeding red water & zircon sand.

1130 Red water @ 1.035 kg = 516 g/hr

1142 Occasionally getting CO spikes. These spikes occur when BOF mat'l is pulled, but also spikes during normal operation. Slug of red water possibly.

1200 Red Water @ 1.302 kg = 534 g/hr.

1215 Red Water @ 1.443 kg = 564 g/hr

Change Conditions: No problems @ 700°C
- Increase bed temp to 750°C
- All other parameters the same
  - Feeding Red Water ~500 g/hr
  - Zircon Sand. ~3100 g/hr

1230 Red Water @ 1.565 kg = 526 g/hr.

1237 Note: Occasionally bed temps will drop 20-30°C but not split. Seems as if Thermowell has a scale buildup. Tapping Thermowell seems to help.

Note: Noticed Carbon burnout at 700°C was better than at 650°C. Not as many black agglomerates.

1300 Red Water. 1.838 kg = 546 g/hr.

1315 Change Conditions: No problems @ 750°C
- Increase bed temp to 800°C
- All other parameter the same

1320 Change to new batch of red water
2.049 Kg New a025
633. g/hr

2-22-95 SPW B528

1330 Red Water @ 0.068 kg .= 378 g/hr

1335 Discharge some BUF

1338 It appears we are defluidized. Red Water OFF.
Shell temp 860°F while trying to heat bed
to 800°C. Bed temps split.

1341 Dec. shell heat. stirring bed.

1343 Bed is fluid now. Will heat up to 800°C without
Red water addition.

1355 Pulled BOF, mat'l has some hard lumps in it.

1400 BOF not coming out. Zircon feeder off.

Purge to in-bed red water line is plugged.

1408 Stirring bed

1412 Cleared plug at in-bed red water line.

1413 Zircon feeder back on.

1424 Zircon feed off; nothing coming out BOF. Reactor probably full!
Stiring bed & is difinite sticky.

1430 Removed alot of mat'l from BOF, while stirring inside of reactor Very lumpy
& some flat pieces that are hard & yellow. 3029 g

BOF seemed to be blocked from inside reactor.

Shutdown heat off

1447 Removed reactor lid. Mat'l stuck inside reactor with
holes in it - where T well, feedtube & tap
went down.

2-22-95 SDW 8528

1455 Stirring up bed & able to refluidize, Much cooler now. Lumps still floating around in bed.

1516 Able to drain bed out at Bed dump valve, but had to break lumps to do so.
Recovered 5175g + 3029g BOF @ 1430 hrs

2-23-95

0630 Cleaned reactor & heating up.

0654 Adding Al_2O_3 in reactor. 3400g (mix)

0730 Bed ΔP 8" H_2O; well fluidized, bed temps 645°C

0742 Start Al_2O_3 solids
0751 Start Salt sol'n level @ 0.0
BOF open.

0800 Salt Sol'n level @ 0.067kg = 447 g/hr
BOF plugged, cleared & will pull at 0810

0830 Salt Sol'n level @ 0.316 kg = 498 g/hr

0854 Al_2O_3 feed rate slower than zircon feed. because of density. Increase rate to get ~ 50 g/min Currently 34 g/min. 80 → 90% at controller.

0900 Salt Sol'n level @ 0.569 kg ⟶ 506g/hr

0930 Change Conditions: Salts Sol'n 0.823kg ⟶ 634g/hr
- Red Water Feed
- Temp same @ 650°C
- Al_2O_3 feed

2/23/95 SDW 8528

0931 Start Red Water feed

0936 Increase feeder 90 → 95%

0940 Red Water feed tube plugging somewhere.

0945 Dip tube sucking Red Water out of bucket was plugged with salts

Back on

1000 Red Water fuel @ 0.202 kg = 404 g/hr

1023 Red Water feed tube plugging

1024 Pulled tube & cleared.
Outlet of pump plugging with salts

1027 Pump on

1030 Red Water @ 0.408 kg ~ 412 g/hr

1104 Red Water @ 0.711 kg = 534 g/hr

- Change Conditions:
  - Inc. temp to 700°C
  - All else the same.
    - Feeding Red Water ~ 500 g/hr
    - Al_2O_3 mix @ ~ 2400 g/hr.

1120 Occasionally getting CO spikes. at this higher temp.

Note: Agglomerates are bigger today than yesterday when we were feeding Zircon Sand.

1130 Red Water @ @ 0.944 kg = 537 g/hr

1200 Red Water @ 1.212 kg = 536 g/hr

2/23/95 500 8528

1230 Red Water at 1.477 kg = 530 g/hr
Pulled BOF & then will take some
BUF out.

Change Conditions:

- Inc. temp to 750°C
- Feeding RW & Al_2O_3 mix

1245 Red Water line plugged

1246 Back on, line cleared

1253 RW plugged

1257 Back on, line cleared

1300 Redwater @ 1.661 = 368 g/hr
Add New # 0.277

1305 RW plugged

1308 back on, line cleared.

1340 Red Water @ 0.607 = 495 g/hr

1352 Bed T's just split.
T1 709°C
T2 762°C

1358 Red Water off - bottom of bed appears defluidized.

1403 Beds have come together @ 765°C

Change Conditions

- Inc. Bed temps to 800°C

1408 Red Water on @ 0.774 kg
Bed temps split @ 769° & 813°C

1413 Red Water off. With red water on there was no response in gas composition. It was going into reactor but probably in a "dead" area. Cooling T1.

8528 2/23/95 BDW

1416 Bed T's coming back together. (761 & 777°C)

1418 We are now seeing CO spike, CO_2 & Nox.

1422 Dumping some BUF. (777g)

1431 Temps have come back together at 777°C. Will try heating bed up to see if they will split.

1442 Temps lined out at 810°C. Turned on red water. & solids

1447 Temps 780°C

O_2, %	19.8
CO_2, %	0.9
CO, ppm	25
Nox, ppm	1656

1453 Bed currently 801°C, feeding RW & Al_2O_3. No problems.

O_2, %	20.1
CO_2, %	0.6
CO, ppm	26
Nox, ppm	1678

1500 Red Water @ 0.974 kg = 533 g/hr

1507 Change Conditions

• Increase bed to 850°C.

1513 Red Water off 1.099
Bed T's split @ ~ 830°F

Currently 807°F & 839

1514 Observing large CO & CO_2 spikes, also NOx
Shell 860°F. CO_2 to 4.6 %
Cooling bed down to see if fluidization comes back

1523 Bed temps are uniform now @ 728°C. & appears fluid.

8528 2/23/95 SDW

1528 Heat off; Dumping bed thru BUF valve. (free flow)
2343g removed from BUF

2-24-95

0642 Removed reactor lid. Most of the bed was drained out from BUF port. There are some large lumps sitting on top of plate. Some pieces are the shape of tubes going down into reactor

Removed 383g of above mat'l off of plate.

Final Bed 2726 g

The following Samples were selected for particle size and Na analysis

2/22/95 Zircon Sand		2/23/95 Alumina
BOF		BOF
0830 0930	Base Case 1 Salt at 645°C	0830 0930
1000 1100	Base Case 2 Red Water 650°C	1000 1100
1130 1215	Test 1 Red Water @ 695°C	1200 1230
1300 1315	Test 2 Red Water @ 745°C	1300 1400
—	Test 3 Red Water @ 800°C	1500
Final Bed		Final Bed
Final Cyc		Final Cyc

Project 8528, Feb. 22, 1995

		ScanChannel		1	2	3	4	5	7.0	8.0	9.0	10.0	11.0	12.0
		Port.Channel		1001	1002	1003	1004	1005	1013.0	1014.0	1017.0	1018.0	1019.0	1020.0
		Chnl Tag		LowBed	MidBed	FRBRD	CycOut	BGHin	O2	CO2	Co ppm	So2ppm	Noxppm	THCppm
		Chnl Unit		C	C	C	C	C			PPM	PPM		PPM
Month	Day	Hour	Minute											
2	22	7	1	667	724	438	157	115	20.5	0.0	-7.0	-0.3	6.0	8.0
2	22	7	2	653	710	570	162	119	20.5	0.0	-7.0	0.0	5.8	8.0
2	22	7	3	631	684	561	167	120	20.5	0.0	-6.9	0.0	5.7	6.8
2	22	7	4	630	682	543	174	118	20.5	0.0	-6.8	-0.3	6.2	6.8
2	22	7	5	628	675	571	182	117	20.5	0.0	-6.7	0.0	6.3	6.8
2	22	7	6	156	466	551	181	119	20.5	0.0	-6.6	0.0	5.9	6.8
2	22	7	7	252	318	530	185	122	20.5	0.0	-6.6	0.1	6.4	6.8
2	22	7	8	318	351	515	184	125	20.5	0.0	-6.6	-0.5	6.2	6.8
2	22	7	9	376	398	498	182	129	20.5	0.0	-6.3	-0.3	6.2	5.8
2	22	7	10	425	441	578	183	132	20.5	0.0	-5.7	-0.3	5.8	5.8
2	22	7	11	470	482	561	195	135	20.5	0.0	-5.8	0.1	6.0	7.5
2	22	7	12	509	522	601	196	138	20.5	0.0	-5.9	-0.4	6.4	5.8
2	22	7	13	548	554	613	199	141	20.5	0.0	-6.3	-0.1	6.2	5.0
2	22	7	14	581	585	624	204	143	20.5	0.0	-6.0	0.0	6.2	5.0
2	22	7	15	603	606	630	206	145	20.5	0.0	-5.6	0.2	6.5	5.1
2	22	7	16	616	621	631	209	148	20.5	0.0	-6.1	0.2	6.3	5.0
2	22	7	17	625	632	631	211	150	20.5	0.0	-6.1	0.0	6.3	5.8
2	22	7	18	633	638	629	216	151	20.5	0.0	-5.9	0.2	6.3	5.0
2	22	7	19	634	641	626	219	153	20.5	0.0	-5.9	-0.3	6.2	5.0
2	22	7	20	637	644	623	221	155	20.5	0.0	-6.1	0.3	6.1	5.0
2	22	7	21	641	648	621	223	157	20.5	0.0	-6.0	0.3	6.2	5.0
2	22	7	22	640	647	616	225	159	20.5	0.0	-5.6	-0.1	6.0	5.0
2	22	7	23	642	647	616	231	160	20.5	0.0	-5.4	0.1	6.3	4.0
2	22	7	24	642	645	616	235	161	20.5	0.0	-5.2	0.1	6.4	4.0
2	22	7	25	642	646	614	237	163	20.5	0.0	-5.5	0.1	6.5	4.0
2	22	7	26	640	646	611	240	165	20.5	0.0	-5.7	0.1	6.5	4.0
2	22	7	27	642	648	611	240	167	20.5	0.0	-5.6	0.2	6.4	10.8
2	22	7	28	640	648	609	241	170	20.5	0.0	-5.6	0.1	6.0	1.1
2	22	7	29	640	649	609	242	171	20.5	0.0	-6.1	0.2	6.3	1.1
2	22	7	30	640	648	607	245	173	20.5	0.0	-6.3	0.3	6.4	1.1
2	22	7	31	641	647	609	249	174	20.5	0.0	-6.0	-0.1	6.2	1.1
2	22	7	32	640	646	609	251	175	20.5	0.0	-5.9	-0.2	6.3	1.1
2	22	7	33	638	646	610	253	177	20.5	0.0	-6.0	0.1	6.0	1.1
2	22	7	34	639	648	609	254	178	20.4	0.1	8.0	0.0	17.2	1.1
2	22	7	35	639	649	606	255	180	20.5	0.0	-3.3	-0.1	9.8	1.1
2	22	7	36	639	638	604	255	182	20.5	0.0	-4.2	0.0	9.1	1.1
2	22	7	37	639	640	609	256	183	20.5	0.0	-3.8	0.1	9.2	1.1
2	22	7	38	639	639	608	256	185	20.5	0.0	-4.0	0.4	9.1	1.1
2	22	7	39	639	640	609	257	185	20.5	0.0	-3.9	0.3	9.0	1.1
2	22	7	40	640	639	610	262	186	20.5	0.0	-3.9	0.2	9.6	1.1
2	22	7	41	638	639	610	263	187	20.5	0.0	-4.8	0.1	9.3	1.1
2	22	7	42	639	639	610	264	188	20.5	0.0	-4.8	-0.2	8.8	1.1
2	22	7	43	638	639	611	266	190	20.5	0.0	-4.7	0.2	8.8	1.1
2	22	7	44	637	638	610	266	191	20.5	0.0	-4.3	0.2	9.0	1.1
2	22	7	45	637	637	610	266	192	20.5	0.0	-4.5	-0.2	9.2	1.1
2	22	7	46	638	638	611	266	193	20.5	0.0	-4.0	0.0	9.3	1.1
2	22	7	47	637	638	610	266	195	20.5	0.0	-4.2	0.0	8.8	1.1
2	22	7	48	642	643	615	267	196	20.5	0.0	-4.3	0.0	8.9	0.1
2	22	7	49	646	646	617	270	195	20.5	0.0	-3.8	0.2	8.8	0.1
2	22	7	50	646	648	620	272	196	20.5	0.0	-4.8	-0.1	8.6	1.1
2	22	7	51	648	649	622	273	197	20.5	0.0	-4.8	-0.3	8.8	0.1
2	22	7	52	642	643	623	275	198	20.5	0.0	-4.6	-0.1	8.9	2.0
2	22	7	53	634	636	626	277	199	20.5	0.1	10.2	1.0	647.9	0.1
2	22	7	54	630	630	625	278	199	20.5	0.1	14.9	1.5	1110.2	0.1
2	22	7	55	626	627	625	278	201	20.5	0.1	10.8	2.2	1354.6	0.1
2	22	7	56	627	627	627	278	202	20.5	0.1	8.3	2.4	1506.0	0.1
2	22	7	57	630	631	631	282	203	20.5	0.0	7.5	2.6	1632.0	0.1
2	22	7	58	634	634	633	287	204	20.5	0.0	9.2	2.6	1674.4	0.1
2	22	7	59	636	636	636	289	205	20.5	0.0	7.0	2.6	1603.7	0.1
2	22	8	0	636	638	636	290	206	20.5	0.0	6.6	2.9	1616.6	0.1

2	22	8	1	637	638	638	291	208	20.5	0.0	7.3	3.0	1649.5	0.1
2	22	8	2	636	638	639	292	209	20.5	0.0	8.1	2.9	1697.5	0.1
2	22	8	3	637	637	639	292	210	20.5	0.0	7.3	2.9	1703.8	0.1
2	22	8	4	637	638	640	293	211	20.5	0.0	7.2	2.9	1731.8	0.1
2	22	8	5	638	639	640	293	212	20.5	0.0	7.3	3.0	1755.7	0.1
2	22	8	6	637	637	641	295	212	20.5	0.0	6.8	2.9	1815.4	0.1
2	22	8	7	637	638	640	301	213	20.5	0.0	6.6	2.9	1826.5	0.1
2	22	8	8	638	638	640	300	214	20.5	0.0	7.5	2.8	1731.0	0.1
2	22	8	9	638	639	640	302	215	20.5	0.0	5.1	3.0	1685.4	0.1
2	22	8	10	637	637	640	303	217	20.5	0.0	4.6	2.8	1685.9	0.1
2	22	8	11	636	637	640	302	218	20.5	0.0	6.1	2.7	1735.0	0.1
2	22	8	12	637	636	639	302	218	20.5	0.0	7.4	2.6	1750.1	0.1
2	22	8	13	636	636	639	302	219	20.5	0.0	6.6	2.7	1790.0	0.1
2	22	8	14	635	635	639	302	220	20.5	0.0	6.6	3.0	1822.9	0.1
2	22	8	15	635	635	639	302	220	20.5	0.0	7.0	2.8	1831.5	0.1
2	22	8	16	636	636	640	304	221	20.5	0.0	7.0	3.0	1882.8	0.1
2	22	8	17	634	636	638	308	221	20.5	0.0	5.8	2.9	1803.7	0.1
2	22	8	18	639	639	642	309	222	20.5	0.0	5.7	3.1	1768.0	0.1
2	22	8	19	639	639	643	308	223	20.5	0.0	5.6	3.0	1777.0	0.1
2	22	8	20	639	640	644	308	224	20.5	0.0	5.6	2.9	1789.6	0.1
2	22	8	21	643	643	648	310	225	20.5	0.0	6.0	3.1	1838.0	0.1
2	22	8	22	645	644	649	308	225	20.5	0.0	6.9	3.0	1869.8	0.1
2	22	8	23	648	648	650	309	226	20.5	0.0	6.9	2.9	1909.4	0.1
2	22	8	24	648	649	652	307	226	20.5	0.0	6.3	2.9	1924.2	0.1
2	22	8	25	650	651	652	311	226	20.5	0.0	6.8	2.8	1939.2	0.1
2	22	8	26	651	651	653	315	227	20.5	0.0	5.3	3.3	1876.9	0.1
2	22	8	27	651	651	654	314	227	20.5	0.0	4.2	3.6	1840.7	0.1
2	22	8	28	651	651	652	315	228	20.5	0.0	4.5	2.8	1810.2	0.1
2	22	8	29	650	650	652	315	229	20.5	0.0	4.3	3.0	1813.7	0.1
2	22	8	30	649	649	652	316	229	20.5	0.0	4.9	2.6	1817.0	0.1
2	22	8	31	649	650	653	314	230	20.5	0.0	4.8	2.6	1829.1	0.1
2	22	8	32	648	649	653	314	230	20.5	0.0	4.7	3.0	1875.7	0.1
2	22	8	33	647	647	652	315	231	20.5	0.0	5.5	3.0	1915.4	0.1
2	22	8	34	647	648	653	313	231	20.5	0.0	4.9	3.2	1946.0	0.1
2	22	8	35	649	650	653	316	230	20.5	0.0	4.6	3.0	1947.5	0.1
2	22	8	36	649	649	652	317	231	20.5	0.0	3.8	2.8	1873.4	0.1
2	22	8	37	648	649	652	310	232	20.5	0.0	3.5	2.7	1833.7	0.1
2	22	8	38	648	648	653	304	233	20.5	0.0	3.3	3.0	1816.0	0.1
2	22	8	39	646	647	651	297	234	20.5	0.0	3.8	2.8	1827.8	0.1
2	22	8	40	646	646	652	291	234	20.5	0.0	3.8	2.6	1836.2	0.1
2	22	8	41	645	645	652	285	234	20.5	0.0	4.5	2.7	1863.8	0.1
2	22	8	42	645	646	652	280	235	20.5	0.0	5.1	3.0	1901.8	0.1
2	22	8	43	644	645	652	274	235	20.5	0.0	4.5	2.9	1885.9	0.1
2	22	8	44	645	645	652	269	235	20.5	0.0	5.3	3.0	1934.6	0.1
2	22	8	45	646	646	651	266	235	20.5	0.0	3.2	3.0	1881.5	0.1
2	22	8	46	646	647	652	263	236	20.5	0.0	2.8	3.5	1819.1	0.1
2	22	8	47	646	647	651	261	236	20.5	0.0	3.4	2.5	1797.4	0.1
2	22	8	48	646	646	651	258	237	20.5	0.0	3.0	2.8	1812.0	0.1
2	22	8	49	647	648	652	254	237	20.5	0.0	2.7	2.8	1844.2	0.1
2	22	8	50	648	648	652	253	238	20.5	0.0	3.2	3.0	1889.4	0.1
2	22	8	51	648	648	650	250	238	20.5	0.0	3.5	3.1	1895.3	0.1
2	22	8	52	648	648	651	247	238	20.5	0.0	3.1	3.1	1939.2	0.1
2	22	8	53	652	651	652	245	237	20.5	0.0	3.9	3.1	1976.9	0.1
2	22	8	54	653	653	651	242	238	20.5	0.0	3.0	3.4	1934.5	0.1
2	22	8	55	653	652	649	239	238	20.5	0.0	2.4	2.9	1864.8	0.1
2	22	8	56	654	654	649	237	239	20.5	0.0	2.4	2.9	1855.6	0.1
2	22	8	57	654	655	649	324	240	20.5	0.0	2.7	2.7	1866.5	0.1
2	22	8	58	655	655	649	320	239	20.5	0.0	3.6	2.7	1908.6	0.1
2	22	8	59	654	654	648	320	239	20.5	0.0	3.9	3.1	1940.6	0.1
2	22	9	0	653	653	646	318	239	20.5	0.0	3.1	3.2	1954.8	0.1
2	22	9	1	655	654	647	319	239	20.5	0.0	3.9	3.1	1975.6	0.1
2	22	9	2	656	656	645	320	239	20.5	0.0	6.8	3.1	2002.3	0.1
2	22	9	3	655	657	645	322	239	20.5	0.0	3.6	2.9	1929.5	0.1
2	22	9	4	657	657	642	321	239	20.5	0.0	2.6	2.7	1888.1	0.1
2	22	9	5	658	658	643	322	240	20.5	0.0	2.9	3.1	1867.0	0.1
2	22	9	6	658	658	642	321	240	20.5	0.0	3.0	3.1	1879.8	0.1
2	22	9	7	656	656	641	319	240	20.5	0.0	3.3	3.1	1932.0	0.1

2	22	9	8	656	656	640	319	240	20.5	0.0	4.8	3.4	1947.9	0.1
2	22	9	9	653	653	640	317	240	20.5	0.0	6.7	3.4	1947.9	0.1
2	22	9	10	652	652	640	319	239	20.5	0.0	6.9	3.2	1981.6	0.1
2	22	9	11	651	651	640	319	239	20.5	0.0	5.6	3.0	1958.6	0.1
2	22	9	12	650	650	641	322	240	20.5	0.0	5.9	2.8	1874.6	0.1
2	22	9	13	647	647	640	321	240	20.5	0.0	4.1	2.8	1822.7	0.1
2	22	9	14	645	646	640	321	240	20.5	0.0	4.9	2.8	1848.5	0.1
2	22	9	15	645	645	640	321	240	20.5	0.0	4.5	2.9	1868.1	0.1
2	22	9	16	643	643	640	320	240	20.5	0.0	4.9	2.9	1902.0	0.1
2	22	9	17	641	641	641	319	240	20.5	0.0	5.1	2.7	1910.8	0.1
2	22	9	18	644	644	641	321	240	20.5	0.0	5.8	3.0	1933.4	0.1
2	22	9	19	643	644	641	325	240	20.5	0.0	6.5	3.1	1907.0	0.1
2	22	9	20	645	645	641	331	241	20.5	0.0	4.4	3.2	1821.2	0.1
2	22	9	21	643	644	641	332	242	20.5	0.0	111.2	3.3	1765.3	0.1
2	22	9	22	642	644	643	333	243	20.5	0.0	8.8	2.3	1712.3	0.1
2	22	9	23	642	643	646	334	244	20.5	0.0	3.5	2.7	1695.7	0.1
2	22	9	24	635	637	644	333	244	20.5	0.0	5.2	2.8	1695.4	0.1
2	22	9	25	634	635	644	333	245	20.5	0.0	4.5	2.8	1703.5	0.1
2	22	9	26	632	633	644	331	245	20.5	0.0	5.3	2.8	1748.8	0.1
2	22	9	27	630	631	644	332	245	20.5	0.0	5.7	3.1	1793.0	0.1
2	22	9	28	635	636	646	338	246	20.5	0.0	4.6	3.0	1805.0	0.1
2	22	9	29	635	637	647	339	247	20.5	0.0	2.8	3.3	1721.8	0.1
2	22	9	30	637	638	648	339	247	20.5	0.0	3.7	2.4	1672.3	0.1
Average Base Case 1				645	645	646	304	232	20.5	0.0	6	3	1840	0
2	22	9	31	641	642	649	339	248	20.5	0.0	20.2	2.6	1605.7	9.0
2	22	9	32	644	645	651	339	248	19.9	0.6	426.7	2.9	1861.8	9.0
2	22	9	33	646	646	652	338	249	19.9	0.8	456.4	2.7	1863.1	8.0
2	22	9	34	646	647	653	335	249	19.8	0.9	466.7	2.9	1860.9	5.8
2	22	9	35	648	649	652	338	249	19.8	0.9	509.8	2.8	1883.1	5.8
2	22	9	36	651	652	653	343	250	19.8	0.9	444.4	3.3	1837.5	5.0
2	22	9	37	651	653	653	344	250	19.9	0.8	389.2	2.9	1788.5	5.0
2	22	9	38	650	651	653	344	251	19.9	0.8	392.0	2.9	1772.4	5.8
2	22	9	39	647	651	653	343	251	19.9	0.8	406.1	3.0	1770.5	9.9
2	22	9	40	651	652	653	342	252	19.8	0.9	450.2	2.6	1791.6	4.0
2	22	9	41	650	652	653	341	252	19.9	0.8	401.9	2.4	1752.9	4.0
2	22	9	42	650	651	654	340	252	19.8	0.9	461.4	2.6	1793.9	5.0
2	22	9	43	650	651	654	342	251	19.8	0.9	437.1	2.5	1769.8	5.7
2	22	9	44	652	653	655	346	252	19.8	0.9	434.1	2.7	1777.4	4.8
2	22	9	45	650	652	655	345	253	19.9	0.8	395.5	2.5	1752.7	4.9
2	22	9	46	650	652	654	345	253	19.8	0.9	491.2	2.6	1813.5	5.0
2	22	9	47	651	652	655	344	253	19.9	0.8	388.1	2.5	1742.1	5.0
2	22	9	48	650	651	655	343	253	19.9	0.8	398.8	2.7	1721.3	4.1
2	22	9	49	650	650	655	341	253	19.8	0.9	400.3	3.1	1737.6	4.0
2	22	9	50	649	650	656	342	253	19.8	0.9	425.8	2.4	1750.6	4.4
2	22	9	51	651	652	655	344	253	19.8	0.9	463.2	2.7	1796.6	4.0
2	22	9	52	655	656	654	344	253	19.8	0.8	560.3	2.6	1845.7	0.1
2	22	9	53	658	659	654	346	253	20.2	0.5	244.7	2.6	1209.8	5.0
2	22	9	54	655	655	654	344	254	19.9	0.7	364.5	2.4	1476.5	5.7
2	22	9	55	655	655	655	343	254	19.8	0.8	429.1	2.3	1647.9	3.0
2	22	9	56	652	653	654	342	254	19.9	0.8	379.8	2.9	1680.6	3.2
2	22	9	57	650	651	655	341	254	19.8	0.8	418.0	2.7	1731.9	4.0
2	22	9	58	651	651	654	339	253	19.8	0.9	450.8	2.2	1767.1	5.0
2	22	9	59	652	653	656	344	254	19.8	0.9	435.6	2.6	1764.3	41.5
2	22	10	0	651	653	656	346	254	19.5	1.4	843.5	2.9	1846.9	3.0
2	22	10	1	651	653	654	346	254	19.8	0.9	502.1	2.8	1657.6	3.9
2	22	10	2	651	652	655	346	255	19.8	0.9	464.0	2.2	1659.9	3.0
2	22	10	3	648	649	656	345	255	19.8	0.9	428.4	2.8	1656.6	4.0
2	22	10	4	649	649	655	342	255	19.7	1.0	429.7	2.3	1706.5	5.0
2	22	10	5	649	649	656	340	255	19.7	1.0	430.3	2.7	1734.3	5.0
2	22	10	6	650	651	656	343	254	19.7	1.0	432.2	2.4	1760.7	5.1
2	22	10	7	653	653	655	347	254	19.8	0.9	418.2	2.1	1779.7	4.0
2	22	10	8	651	653	655	346	255	19.8	0.8	411.0	2.4	1781.4	11.7
2	22	10	9	650	651	655	346	255	19.8	0.9	477.8	2.8	1844.9	5.0
2	22	10	10	651	653	655	344	255	19.8	0.9	438.0	2.9	1816.5	5.0
2	22	10	11	651	650	655	344	255	19.6	1.0	558.2	3.0	1902.3	4.0
2	22	10	12	650	652	655	342	255	19.7	1.0	499.3	3.0	1875.4	5.0
2	22	10	13	651	652	656	341	255	19.7	1.0	448.2	2.3	1850.0	4.0

2	22	10	14	651	652	656	342	254	19.7	0.9	433.8	2.9	1851.8	8.0
2	22	10	15	652	654	656	346	255	19.4	1.6	869.6	2.6	1849.6	4.0
2	22	10	16	652	653	655	346	255	19.6	1.1	641.8	2.8	1717.1	4.0
2	22	10	17	652	655	656	346	256	19.6	1.1	593.4	2.4	1701.0	4.0
2	22	10	18	653	655	656	344	256	19.6	1.0	537.3	2.3	1686.6	2.1
2	22	10	19	652	654	656	343	256	19.5	1.1	562.0	2.5	1745.8	2.0
2	22	10	20	651	653	655	342	256	19.8	0.9	404.3	2.8	1630.9	5.0
2	22	10	21	651	653	656	340	255	19.6	1.1	448.7	2.1	1680.0	6.6
2	22	10	22	653	654	655	343	255	19.7	1.1	467.8	2.5	1726.6	4.0
2	22	10	23	653	654	655	347	255	19.8	0.9	368.7	2.6	1688.6	4.0
2	22	10	24	651	653	655	347	256	19.8	0.9	364.3	2.4	1696.3	6.8
2	22	10	25	652	654	655	345	256	19.8	0.9	391.9	2.8	1727.7	4.3
2	22	10	26	652	653	655	345	256	19.8	0.9	390.0	2.5	1738.7	4.0
2	22	10	27	650	650	655	344	256	19.8	1.0	403.4	2.5	1760.1	4.0
2	22	10	28	651	652	656	341	256	19.7	1.0	444.4	2.6	1803.6	5.0
2	22	10	29	651	652	656	341	255	19.7	1.1	454.3	2.7	1808.8	4.0
2	22	10	30	652	653	655	344	255	19.7	1.1	450.6	2.6	1814.7	5.9
2	22	10	31	652	654	655	344	255	19.8	1.0	435.3	2.7	1825.9	5.8
2	22	10	32	653	655	655	346	256	19.8	0.9	424.8	2.7	1811.1	3.3
2	22	10	33	652	653	655	345	256	19.8	0.9	403.7	2.3	1785.1	4.0
2	22	10	34	652	652	655	344	256	19.8	1.0	438.1	2.5	1820.1	5.0
2	22	10	35	652	651	656	342	255	19.7	1.0	470.4	2.5	1860.0	5.8
2	22	10	36	651	652	656	341	255	19.7	1.0	453.9	2.9	1848.5	4.0
2	22	10	37	651	652	656	341	255	19.3	1.1	779.3	3.1	2009.4	4.0
2	22	10	38	652	653	656	345	255	19.7	1.1	466.3	2.9	1888.9	7.9
2	22	10	39	653	654	656	345	255	19.3	1.5	1010.6	3.1	2077.7	4.0
2	22	10	40	652	654	656	346	255	19.6	1.1	709.4	2.6	1777.7	4.0
2	22	10	41	651	653	656	345	256	19.6	1.1	647.1	2.7	1732.8	3.9
2	22	10	42	653	654	656	343	256	19.6	1.1	561.3	2.6	1696.0	3.0
2	22	10	43	653	656	658	342	255	19.6	1.1	544.5	2.8	1691.6	3.0
2	22	10	44	653	654	657	340	255	19.6	1.1	508.3	2.6	1686.1	3.0
2	22	10	45	654	655	655	342	255	19.6	1.2	470.0	2.4	1682.7	5.8
2	22	10	46	656	657	656	346	255	19.7	1.1	433.6	2.8	1726.8	4.3
2	22	10	47	655	656	655	345	255	19.8	0.9	402.5	2.5	1734.0	5.0
2	22	10	48	655	656	655	344	256	19.8	0.9	390.6	2.5	1726.3	4.7
2	22	10	49	653	655	655	344	256	19.7	1.0	419.3	2.5	1757.6	4.0
2	22	10	50	654	655	656	342	255	19.7	1.0	435.7	2.6	1794.2	4.0
2	22	10	51	654	655	657	341	255	19.7	1.0	434.1	2.5	1800.9	4.0
2	22	10	52	653	655	655	341	255	19.7	1.1	434.2	2.8	1793.9	5.0
2	22	10	53	655	656	655	343	255	19.6	1.1	463.6	2.1	1819.5	5.0
2	22	10	54	656	657	655	345	255	19.7	1.0	443.7	2.6	1814.8	4.3
2	22	10	55	655	656	655	346	255	19.8	0.9	393.8	2.7	1781.0	5.8
2	22	10	56	653	654	655	345	256	19.8	0.9	435.0	2.6	1812.1	4.0
2	22	10	57	653	653	655	343	256	19.8	0.9	406.5	3.2	1798.1	3.9
2	22	10	58	654	655	654	342	256	19.8	0.9	410.9	2.7	1800.4	5.9
2	22	10	59	653	654	656	341	255	19.7	1.1	537.2	2.4	1897.9	5.8
Average Case Case 2				**651**	**653**	**655**	**343**	**254**	**19.8**	**0.9**	**464**	**3**	**1768**	**5**
2	22	11	0	653	652	656	343	255	19.7	1.0	461.7	2.8	1883.8	4.0
2	22	11	1	656	655	657	345	255	19.7	1.0	489.4	3.1	1893.4	4.0
2	22	11	2	660	662	661	347	256	19.4	0.9	661.1	2.7	1910.9	2.2
2	22	11	3	665	666	666	347	256	19.5	1.2	734.9	2.7	1738.7	1.8
2	22	11	4	668	669	668	347	256	19.6	1.1	627.0	2.5	1661.9	1.1
2	22	11	5	670	672	670	346	256	19.6	1.1	569.9	2.3	1628.2	0.7
2	22	11	6	676	677	674	344	256	19.5	1.1	513.9	2.6	1620.3	0.1
2	22	11	7	683	685	680	344	256	19.6	1.2	419.0	2.5	1638.9	0.1
2	22	11	8	688	690	682	348	256	19.5	1.2	417.4	2.5	1660.9	0.1
2	22	11	9	693	694	683	351	256	19.7	1.0	360.7	2.3	1669.1	1.1
2	22	11	10	693	695	683	351	257	19.8	0.9	353.5	2.3	1693.1	0.1
2	22	11	11	693	694	685	352	257	19.8	0.9	325.4	2.6	1705.3	0.1
2	22	11	12	694	695	685	351	257	19.8	0.9	323.5	2.5	1714.7	0.1
2	22	11	13	695	696	685	350	257	19.7	1.0	344.4	2.6	1718.6	0.1
2	22	11	14	697	698	686	349	257	19.7	1.0	357.6	2.7	1751.7	0.1
2	22	11	15	697	700	686	349	257	19.7	1.1	344.8	2.9	1793.4	0.1
Start Test 1														
2	22	11	16	700	702	686	353	257	19.7	1.1	366.0	2.8	1821.8	0.1
2	22	11	17	701	703	685	354	257	19.7	1.0	357.2	2.5	1797.6	0.1
2	22	11	18	703	705	685	354	258	19.8	0.9	330.8	2.7	1785.1	0.1

2	22	11	19	701	704	685	353	258	19.8	0.9	324.7	2.7	1783.5	0.1
2	22	11	20	703	704	685	351	258	19.7	1.0	352.4	2.9	1809.7	0.1
2	22	11	21	702	704	684	350	258	19.7	1.0	375.8	2.7	1844.7	0.1
2	22	11	22	704	706	684	349	258	19.6	1.0	368.0	2.7	1846.6	0.1
2	22	11	23	704	706	684	351	258	19.7	1.1	353.4	2.8	1873.6	0.1
2	22	11	24	706	707	683	355	258	19.7	1.0	347.5	2.8	1879.4	0.1
2	22	11	25	708	708	683	355	259	19.8	0.9	351.3	3.1	1858.4	0.1
2	22	11	26	708	710	683	354	259	19.8	0.8	330.8	2.8	1857.3	0.1
2	22	11	27	708	709	683	350	259	19.7	0.9	349.7	3.0	1874.1	0.1
2	22	11	28	707	710	682	350	259	19.6	1.1	390.0	3.1	1958.2	0.1
2	22	11	29	704	709	681	353	259	19.8	1.0	375.5	3.0	1941.1	0.1
2	22	11	30	677	683	679	356	259	19.8	0.9	380.5	2.8	1926.5	0.1
2	22	11	31	669	670	680	356	259	19.6	0.8	546.7	2.6	1934.7	0.1
2	22	11	32	691	692	680	353	260	19.5	1.3	753.3	2.6	1739.8	0.1
2	22	11	33	698	699	679	351	260	19.5	1.1	678.9	2.9	1735.6	0.1
2	22	11	34	685	688	679	352	259	19.5	1.2	634.4	2.6	1723.4	0.1
2	22	11	35	679	681	678	353	259	19.6	1.1	567.9	2.7	1698.5	1.1
2	22	11	36	694	695	677	356	259	19.7	1.1	423.8	2.7	1713.5	1.1
2	22	11	37	694	697	676	357	260	19.8	0.9	359.2	2.6	1732.9	1.1
2	22	11	38	683	684	676	358	261	19.8	0.8	356.7	2.7	1763.0	1.1
2	22	11	39	679	680	675	356	261	19.8	0.8	384.7	2.9	1755.5	2.0
2	22	11	40	688	689	676	355	261	19.8	0.9	372.1	2.6	1749.4	1.1
2	22	11	41	689	690	676	353	261	19.8	0.9	377.0	2.6	1767.1	1.1
2	22	11	42	690	691	677	352	260	19.7	1.0	393.6	2.6	1788.5	0.2
2	22	11	43	692	694	677	355	260	19.7	1.1	414.6	2.8	1805.5	1.1
2	22	11	44	692	694	677	358	261	19.8	0.9	378.1	2.8	1782.4	1.1
2	22	11	45	691	692	675	358	261	19.8	0.9	374.9	2.3	1783.1	1.1
2	22	11	46	689	690	677	358	262	19.8	0.8	378.9	2.7	1786.3	1.2
2	22	11	47	686	687	678	356	262	19.8	0.9	393.6	2.9	1800.6	0.1
2	22	11	48	685	687	678	356	262	19.8	0.9	378.6	2.6	1779.2	1.1
2	22	11	49	683	684	679	354	261	19.7	1.0	394.7	2.7	1792.8	1.1
2	22	11	50	682	683	679	354	261	19.7	1.0	410.2	2.6	1800.7	1.1
2	22	11	51	685	686	680	358	261	19.7	1.0	398.1	2.5	1793.6	1.1
2	22	11	52	683	684	679	360	262	19.8	0.8	374.5	2.8	1778.6	0.1
2	22	11	53	684	686	681	360	262	19.7	1.1	629.7	2.6	1683.7	0.1
2	22	11	54	686	687	683	360	263	19.7	1.0	560.2	2.3	1668.9	0.1
2	22	11	55	685	686	684	358	262	19.7	1.0	502.9	2.4	1644.3	0.1
2	22	11	56	685	687	685	356	262	19.7	1.0	444.5	2.4	1650.0	0.1
2	22	11	57	685	687	685	354	262	19.6	1.1	417.0	2.3	1682.3	0.1
2	22	11	58	688	688	684	357	262	19.7	1.0	394.6	2.5	1728.9	0.2
2	22	11	59	691	693	685	361	262	19.8	0.9	364.1	2.6	1707.2	0.1
2	22	12	0	691	693	685	361	263	19.9	0.8	342.7	2.5	1697.8	0.1
2	22	12	1	689	690	685	360	263	19.9	0.8	317.5	2.6	1700.6	0.1
2	22	12	2	688	689	684	359	263	19.8	0.9	345.1	2.8	1708.7	0.1
2	22	12	3	688	689	686	357	263	19.8	0.9	371.2	3.0	1728.9	0.1
2	22	12	4	688	689	686	356	263	19.8	1.0	352.9	2.8	1729.5	0.1
2	22	12	5	690	692	686	357	262	19.7	1.0	361.7	2.5	1741.8	0.1
2	22	12	6	693	696	687	361	262	19.7	1.0	363.7	3.0	1755.2	0.1
2	22	12	7	695	697	688	361	263	19.8	0.8	337.1	3.1	1742.6	0.1
2	22	12	8	695	697	689	360	263	19.8	0.8	353.9	2.6	1766.4	0.1
2	22	12	9	693	694	690	360	263	19.8	0.8	332.1	2.9	1755.1	0.1
2	22	12	10	687	688	689	359	263	19.8	0.9	352.7	2.7	1762.9	0.1
2	22	12	11	686	687	690	356	263	19.8	0.9	355.2	2.6	1752.5	0.1
2	22	12	12	687	688	691	359	263	19.7	0.9	352.4	2.5	1771.9	0.1
2	22	12	13	687	689	690	361	263	19.8	0.9	355.1	2.9	1789.4	0.1
2	22	12	14	688	689	690	363	264	19.7	1.0	585.9	2.7	1688.6	0.1
2	22	12	15	689	691	690	362	264	19.7	0.9	544.0	2.8	1652.8	0.1
Average Test 1				**691**	**693**	**683**	**356**	**261**	**19.7**	**1.0**	**407**	**3**	**1773**	**0**
2	22	12	16	690	692	692	362	264	19.7	0.9	482.0	2.4	1627.0	0.1
2	22	12	17	689	690	693	361	264	19.7	0.9	395.7	2.3	1593.8	0.1
2	22	12	18	693	695	696	361	264	19.7	1.0	356.4	2.5	1640.8	0.1
2	22	12	19	700	701	700	365	264	19.8	0.9	310.8	2.7	1669.4	0.1
2	22	12	20	706	708	706	367	265	19.8	0.9	290.8	2.6	1700.5	0.1
2	22	12	21	711	714	712	366	265	19.8	0.9	283.8	3.2	1710.0	0.1
2	22	12	22	711	716	716	366	266	19.8	0.9	268.9	2.8	1732.7	0.1
2	22	12	23	667	674	719	369	266	19.8	0.9	255.5	3.1	1740.8	0.1
2	22	12	24	688	688	720	366	266	19.7	1.0	279.9	2.6	1652.3	0.1

2	22	12	25	704	707	722	365	265	19.7	1.0	276.5	2.9	1726.0	0.1
2	22	12	26	713	715	724	367	265	19.6	1.1	278.0	2.7	1788.2	0.1
2	22	12	27	718	720	723	371	266	19.8	0.9	260.9	3.1	1802.8	0.1
2	22	12	28	715	721	725	373	266	19.8	0.9	258.5	3.1	1806.5	0.1
2	22	12	29	683	685	726	373	267	19.8	0.8	280.2	2.8	1767.9	0.1
2	22	12	30	707	708	726	372	267	19.7	0.9	277.8	2.9	1743.3	0.1
2	22	12	31	715	717	727	371	267	19.8	0.9	247.3	2.8	1782.1	0.1
2	22	12	32	719	720	728	370	267	19.7	1.0	246.2	3.1	1838.6	0.1
2	22	12	33	721	722	727	367	266	19.7	1.0	254.0	3.0	1870.6	0.1
2	22	12	34	728	730	730	372	267	19.7	1.0	247.9	2.9	1882.1	0.1
2	22	12	35	731	731	729	375	267	19.8	0.9	258.3	3.3	1891.2	0.1
2	22	12	36	732	734	733	377	268	19.8	0.8	248.8	2.9	1891.0	0.1
2	22	12	37	736	738	735	377	268	19.8	0.8	233.0	2.9	1895.6	0.1
2	22	12	38	739	741	739	377	269	19.8	0.9	211.6	2.8	1913.2	0.1
2	22	12	39	739	739	742	375	269	19.7	0.9	217.3	3.3	1945.6	0.1
2	22	12	40	740	741	744	374	268	19.8	0.9	178.5	2.9	1934.5	0.1
2	22	12	41	742	744	747	373	268	19.7	1.0	208.8	3.2	2007.5	0.1
2	22	12	42	742	744	745	377	268	19.8	1.0	177.7	3.2	2000.8	0.1
2	22	12	43	739	741	746	380	269	19.8	0.9	195.0	3.7	1988.1	0.1
2	22	12	44	740	741	745	380	270	19.8	0.9	258.9	2.7	2012.0	0.1
2	22	12	45	744	745	747	380	270	19.9	0.8	209.3	3.5	1997.0	0.1
Start Test 2														
2	22	12	46	745	745	749	380	270	19.8	0.8	214.1	3.3	2021.5	0.1
2	22	12	47	747	747	749	379	270	19.7	0.9	243.2	3.1	2077.2	0.1
2	22	12	48	747	748	751	377	270	19.8	0.9	198.9	3.4	2060.5	0.1
2	22	12	49	748	749	751	378	269	19.6	1.0	250.7	3.1	2140.9	0.1
2	22	12	50	747	749	752	381	270	19.3	0.9	463.9	3.4	2104.1	0.1
2	22	12	51	747	750	751	383	270	19.4	1.3	440.5	3.3	1995.7	0.1
2	22	12	52	748	750	751	383	271	19.6	1.1	355.5	2.6	1935.5	0.1
2	22	12	53	748	750	751	382	271	19.6	1.1	295.9	3.2	1911.0	0.1
2	22	12	54	747	750	751	381	271	19.6	1.0	225.6	3.3	1971.3	0.1
2	22	12	55	748	750	752	379	271	19.6	1.0	230.3	3.0	1984.4	0.1
2	22	12	56	751	753	751	379	270	19.6	1.0	209.6	3.4	2024.4	0.1
2	22	12	57	751	754	750	383	271	19.7	1.0	205.2	3.6	2068.9	0.1
2	22	12	58	738	739	750	385	271	19.8	0.9	197.2	3.4	2020.8	0.1
2	22	12	59	744	747	750	384	272	19.8	0.9	222.2	3.4	2001.8	0.1
2	22	13	0	747	749	750	382	272	19.8	0.9	204.5	3.3	2017.9	0.1
2	22	13	1	747	749	750	382	272	19.7	0.9	205.0	3.6	2049.0	0.1
2	22	13	2	748	751	750	380	271	19.7	1.0	201.2	3.4	2040.0	0.1
2	22	13	3	731	733	750	377	271	19.6	1.0	204.3	3.1	2071.1	0.1
2	22	13	4	739	741	751	376	270	19.6	1.1	216.3	3.4	2064.9	0.1
2	22	13	5	745	747	749	380	271	19.6	1.1	223.2	3.7	2090.8	0.1
2	22	13	6	741	743	747	382	271	19.8	0.9	222.4	3.3	2063.8	0.1
2	22	13	7	745	748	748	382	271	19.7	0.9	242.1	3.3	2063.7	0.1
2	22	13	8	746	748	748	380	271	19.7	0.9	231.7	3.5	2054.2	0.1
2	22	13	9	743	745	748	380	271	19.7	0.9	233.1	3.3	2075.6	0.1
2	22	13	10	726	729	748	379	271	19.7	1.0	240.6	3.4	2067.8	0.1
2	22	13	11	727	730	748	377	271	19.7	1.0	247.8	3.4	2055.8	0.1
2	22	13	12	734	737	748	376	270	19.6	1.0	238.6	3.7	2074.5	0.1
2	22	13	13	737	740	748	378	270	19.6	1.0	264.6	3.7	2081.4	0.1
2	22	13	14	738	742	745	380	271	19.6	1.1	425.0	3.3	2017.4	0.1
2	22	13	15	742	744	745	380	271	19.7	1.0	378.2	3.4	1997.1	0.1
Average Test 2				**743**	**745**	**749**	**380**	**271**	**19.7**	**1.0**	**258**	**3**	**2040**	[illegible]
2	22	13	16	741	744	745	378	271	19.6	1.0	306.3	3.2	1961.3	0.1
2	22	13	17	742	743	748	378	271	19.8	0.9	230.1	3.2	2016.7	0.1
2	22	13	18	744	747	749	377	271	19.9	0.8	168.5	3.2	1963.1	0.1
2	22	13	19	748	751	753	377	270	20.0	0.7	131.3	3.0	1952.0	0.1
2	22	13	20	749	752	755	378	270	20.0	0.7	130.1	3.3	1916.9	0.1
2	22	13	21	718	722	756	384	271	20.1	0.6	121.8	2.8	1891.7	0.1
2	22	13	22	711	713	758	385	272	20.0	0.6	226.6	3.2	1903.9	0.1
2	22	13	23	722	724	758	384	272	20.0	0.6	189.6	3.2	1884.7	0.1
2	22	13	24	731	733	759	382	272	20.0	0.6	183.6	3.1	1910.9	0.1
2	22	13	25	737	740	761	380	272	20.0	0.7	183.5	2.8	1947.6	0.1
2	22	13	26	725	730	764	382	272	19.9	0.7	183.7	3.2	1985.8	0.1
2	22	13	27	685	687	768	390	272	20.0	0.7	205.7	3.6	1941.0	0.1
2	22	13	28	679	679	771	389	273	20.0	0.6	196.7	2.9	1832.4	0.1
2	22	13	29	691	693	773	387	273	20.0	0.6	198.1	3.1	1800.9	0.1

2	22	13	30	704	707	775	385	273	20.0	0.7	203.1	2.9	1839.3	0.1
2	22	13	31	717	719	774	384	273	19.9	0.7	185.8	3.0	1883.0	0.1
2	22	13	32	707	709	772	387	273	20.0	0.7	183.3	3.2	1907.3	0.1
2	22	13	33	722	725	772	382	273	20.0	0.6	231.6	2.9	1889.4	0.1
2	22	13	34	699	710	771	389	274	20.0	0.6	194.5	3.3	1891.1	0.1
2	22	13	35	675	704	771	389	274	20.1	0.6	220.4	3.0	1809.6	0.1
2	22	13	36	664	693	771	387	274	20.0	0.6	181.2	2.7	1699.1	0.1
2	22	13	37	680	687	767	386	273	20.3	0.4	85.4	2.4	1210.9	0.1
2	22	13	38	701	703	758	387	273	20.5	0.1	40.3	1.5	871.4	0.1
2	22	13	39	697	698	741	379	273	20.5	0.0	33.3	1.8	722.2	0.1
2	22	13	40	721	722	729	374	271	20.5	0.0	23.7	1.6	624.1	0.1
2	22	13	41	718	720	722	371	270	20.6	0.0	11.2	1.0	571.0	0.1
2	22	13	42	721	727	713	369	268	20.6	0.0	11.5	1.5	507.5	0.1
2	22	13	43	627	537	645	364	267	20.6	-0.1	8.3	1.2	460.8	0.1
2	22	13	44	578	579	682	362	267	20.6	-0.1	36.6	0.9	424.8	0.1
2	22	13	45	613	614	689	360	266	20.6	-0.1	17.2	0.8	388.8	0.1
2	22	13	46	636	637	693	359	266	20.6	-0.1	15.9	1.0	358.1	0.1
2	22	13	47	654	654	697	357	265	20.6	-0.1	7.9	0.9	342.4	0.1
2	22	13	48	668	668	699	354	264	20.6	-0.1	7.3	1.0	321.1	0.1
2	22	13	49	679	680	700	353	264	20.6	-0.1	7.8	0.7	306.6	0.1
2	22	13	50	688	688	702	349	263	20.6	-0.1	8.4	0.8	289.3	0.1
2	22	13	51	696	696	702	351	262	20.6	-0.1	7.5	0.5	275.2	0.1
2	22	13	52	702	703	702	351	261	20.6	-0.1	6.1	0.6	264.6	0.1
2	22	13	53	707	708	702	351	261	20.6	-0.1	6.8	0.7	255.2	0.1
2	22	13	54	712	713	703	350	261	20.6	-0.1	7.2	0.6	245.0	0.1
2	22	13	55	717	718	706	349	260	20.6	-0.1	7.5	0.6	237.2	0.1
2	22	13	56	722	724	707	348	260	20.6	-0.1	8.5	0.7	228.1	0.1
2	22	13	57	726	726	707	349	259	20.6	-0.1	7.7	0.3	222.3	0.1
2	22	13	58	729	729	708	348	259	20.6	-0.1	9.0	0.5	217.0	0.1
2	22	13	59	731	732	708	348	258	20.6	-0.1	8.9	0.7	210.3	0.1
2	22	14	0	731	734	706	346	258	20.6	-0.1	10.4	0.8	204.9	0.1
2	22	14	1	736	737	708	343	257	20.6	-0.1	9.1	0.6	199.1	0.1
2	22	14	2	738	738	708	341	257	20.6	-0.1	8.6	0.6	194.4	0.1
2	22	14	3	740	741	708	343	256	20.6	-0.1	7.7	0.5	187.7	0.1
2	22	14	4	745	745	709	344	255	20.6	-0.1	6.1	0.7	183.5	0.1
2	22	14	5	745	746	700	336	257	20.6	-0.1	3.1	0.5	180.1	0.1
2	22	14	6	752	754	709	335	256	20.6	-0.1	12.0	0.7	176.2	0.1
2	22	14	7	757	758	708	328	256	20.6	-0.1	1.5	0.3	172.2	0.1
2	22	14	8	764	764	713	334	254	20.6	-0.1	1.7	0.4	168.4	0.1
2	22	14	9	767	767	720	337	252	20.6	-0.1	0.7	0.4	165.9	0.1
2	22	14	10	770	771	719	335	251	20.6	-0.1	0.8	0.7	159.4	0.1
2	22	14	11	771	772	718	336	250	20.6	0.0	2.8	0.3	169.3	0.1
2	22	14	12	772	773	717	337	250	20.6	0.0	0.6	0.6	159.6	0.1
2	22	14	13	769	769	714	336	249	20.6	0.0	0.6	0.3	156.4	0.1
2	22	14	14	762	763	710	336	249	20.6	0.0	6.7	0.3	155.9	0.1
2	22	14	15	757	758	707	336	249	20.6	-0.1	7.3	0.1	149.9	0.1
2	22	14	16	751	751	704	340	248	20.6	-0.1	6.4	0.6	147.6	0.1
2	22	14	17	744	744	701	342	249	20.6	-0.1	5.4	0.6	144.4	0.1
2	22	14	18	739	739	698	341	249	20.6	-0.1	6.4	0.5	141.1	0.1
2	22	14	19	736	736	695	333	249	20.6	-0.1	6.1	0.4	139.0	0.1
2	22	14	20	732	732	691	326	248	20.6	-0.1	6.3	0.6	136.9	0.1
2	22	14	21	727	727	691	319	248	20.6	-0.1	7.7	0.6	134.4	0.1
2	22	14	22	724	724	690	332	248	20.6	-0.1	9.9	0.4	133.8	0.1
2	22	14	23	731	732	694	323	248	20.6	-0.1	12.2	0.1	132.3	0.1
2	22	14	24	752	754	704	317	249	20.6	-0.1	3.7	0.3	131.0	0.1
2	22	14	25	774	778	717	314	249	20.6	-0.1	4.0	0.1	131.3	0.1
2	22	14	26	775	780	716	322	251	20.6	-0.1	0.4	0.3	128.1	0.1
2	22	14	27	753	774	723	316	248	20.6	-0.1	-0.1	0.4	126.5	0.1
2	22	14	28	737	768	723	311	245	20.6	-0.1	-1.4	0.4	121.9	0.1
2	22	14	29	723	758	733	313	244	20.6	-0.1	-1.4	0.1	122.0	0.1
2	22	14	30	709	749	743	332	244	20.6	-0.1	-1.3	0.4	118.9	0.1
2	22	14	31	696	740	749	334	244	20.6	-0.1	-1.5	0.4	117.8	0.1
2	22	14	32	684	730	752	354	244	20.6	-0.1	-2.0	0.4	115.5	0.1
2	22	14	33	670	720	749	354	244	20.6	-0.1	-1.4	0.4	114.6	0.1
2	22	14	34	658	711	739	356	244	20.6	-0.1	-1.4	0.4	112.7	0.1
2	22	14	35	650	701	729	354	244	20.6	-0.1	-1.7	0.3	112.1	0.1
2	22	14	35	637	691	721	353	243	20.6	-0.1	-1.8	0.4	111.6	0.1

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		ScanChannel		1	2	3	4	5	7.0	8.0	9.0	10.0	11.0	12.0
		Port.Channel		1001	1002	1003	1004	1005	1013.0	1014.0	1017.0	1018.0	1019.0	1020.0
		Chnl Tag		LowBed	MidBed	FRBRD	CycOut	BGHin	O2	CO2	Co ppm	So2ppm	Noxppm	THCppm
		Chnl Unit		C	C	C	C	C						
Month	Day	Hour	Minute								PPM	PPM		PPM
2	22	7	1	667	724	438	157	115	20.5	0.0	-7.0	-0.3	6.0	8.0
2	22	7	2	653	710	570	162	119	20.5	0.0	-7.0	0.0	5.8	8.0
2	22	7	3	631	684	561	167	120	20.5	0.0	-6.9	0.0	5.7	6.8
2	22	7	4	630	682	543	174	118	20.5	0.0	-6.8	-0.3	6.2	6.8
2	22	7	5	628	675	571	182	117	20.5	0.0	-6.7	0.0	6.3	6.8
2	22	7	6	156	466	551	181	119	20.5	0.0	-6.6	0.0	5.9	6.8
2	22	7	7	252	318	530	185	122	20.5	0.0	-6.6	0.1	6.4	6.8
2	22	7	8	318	351	515	184	125	20.5	0.0	-6.6	-0.5	6.2	6.8
2	22	7	9	376	398	498	182	129	20.5	0.0	-6.3	-0.3	6.2	5.8
2	22	7	10	425	441	578	183	132	20.5	0.0	-5.7	-0.3	5.8	5.8
2	22	7	11	470	482	561	195	135	20.5	0.0	-5.8	0.1	6.0	7.5
2	22	7	12	509	522	601	196	138	20.5	0.0	-5.9	-0.4	6.4	5.8
2	22	7	13	548	554	613	199	141	20.5	0.0	-6.3	-0.1	6.2	5.0
2	22	7	14	581	585	624	204	143	20.5	0.0	-6.0	0.0	6.2	5.0
2	22	7	15	603	606	630	206	145	20.5	0.0	-5.6	0.2	6.5	5.1
2	22	7	16	616	621	631	209	148	20.5	0.0	-6.1	0.2	6.3	5.0
2	22	7	17	625	632	631	211	150	20.5	0.0	-6.1	0.0	6.3	5.8
2	22	7	18	633	638	629	216	151	20.5	0.0	-5.9	0.2	6.3	5.0
2	22	7	19	634	641	626	219	153	20.5	0.0	-5.9	-0.3	6.2	5.0
2	22	7	20	637	644	623	221	155	20.5	0.0	-6.1	0.3	6.1	5.0
2	22	7	21	641	648	621	223	157	20.5	0.0	-6.0	0.3	6.2	5.0
2	22	7	22	640	647	616	225	159	20.5	0.0	-5.6	-0.1	6.0	5.0
2	22	7	23	642	647	616	231	160	20.5	0.0	-5.4	0.1	6.3	4.0
2	22	7	24	642	645	616	235	161	20.5	0.0	-5.2	0.1	6.4	4.0
2	22	7	25	642	646	614	237	163	20.5	0.0	-5.5	0.1	6.5	4.0
2	22	7	26	640	646	611	240	165	20.5	0.0	-5.7	0.1	6.5	4.0
2	22	7	27	642	648	611	240	167	20.5	0.0	-5.6	0.2	6.4	10.8
2	22	7	28	640	648	609	241	170	20.5	0.0	-5.6	0.1	6.0	1.1
2	22	7	29	640	649	609	242	171	20.5	0.0	-6.1	0.2	6.3	1.1
2	22	7	30	640	648	607	245	173	20.5	0.0	-6.3	0.3	6.4	1.1
2	22	7	31	641	647	609	249	174	20.5	0.0	-6.0	-0.1	6.2	1.1
2	22	7	32	640	646	609	251	175	20.5	0.0	-5.9	-0.2	6.3	1.1
2	22	7	33	638	646	610	253	177	20.5	0.0	-6.0	0.1	6.0	1.1
2	22	7	34	639	648	609	254	178	20.4	0.1	8.0	0.0	17.2	1.1
2	22	7	35	639	649	606	255	180	20.5	0.0	-3.3	-0.1	9.8	1.1
2	22	7	36	639	638	604	255	182	20.5	0.0	-4.2	0.0	9.1	1.1
2	22	7	37	639	640	609	256	183	20.5	0.0	-3.8	0.1	9.2	1.1
2	22	7	38	639	639	608	256	185	20.5	0.0	-4.0	0.4	9.1	1.1
2	22	7	39	639	640	609	257	185	20.5	0.0	-3.9	0.3	9.0	1.1
2	22	7	40	640	639	610	262	186	20.5	0.0	-3.9	0.2	9.6	1.1
2	22	7	41	638	639	610	263	187	20.5	0.0	-4.8	0.1	9.3	1.1
2	22	7	42	639	639	610	264	188	20.5	0.0	-4.8	-0.2	8.8	1.1
2	22	7	43	638	639	611	266	190	20.5	0.0	-4.7	0.2	8.8	1.1
2	22	7	44	637	638	610	266	191	20.5	0.0	-4.3	0.2	9.0	1.1
2	22	7	45	637	637	610	266	192	20.5	0.0	-4.5	-0.2	9.2	1.1
2	22	7	46	638	638	611	266	193	20.5	0.0	-4.0	0.0	9.3	1.1
2	22	7	47	637	638	610	266	195	20.5	0.0	-4.2	0.0	8.8	1.1
2	22	7	48	642	643	615	267	196	20.5	0.0	-4.3	0.0	8.9	0.1
2	22	7	49	646	646	617	270	195	20.5	0.0	-3.8	0.2	8.8	0.1
2	22	7	50	646	648	620	272	196	20.5	0.0	-4.8	-0.1	8.6	1.1
2	22	7	51	648	649	622	273	197	20.5	0.0	-4.8	-0.3	8.8	0.1
2	22	7	52	642	643	623	275	198	20.5	0.0	-4.6	-0.1	8.9	2.0
2	22	7	53	634	636	626	277	199	20.5	0.1	10.2	1.0	647.9	0.1
2	22	7	54	630	630	625	278	199	20.5	0.1	14.9	1.5	1110.2	0.1
2	22	7	55	626	627	625	278	201	20.5	0.1	10.8	2.2	1354.6	0.1
2	22	7	56	627	627	627	278	202	20.5	0.1	8.3	2.4	1506.0	0.1
2	22	7	57	630	631	631	282	203	20.5	0.0	7.5	2.6	1632.0	0.1
2	22	7	58	634	634	633	287	204	20.5	0.0	9.2	2.6	1674.4	0.1
2	22	7	59	636	636	636	289	205	20.5	0.0	7.0	2.6	1603.7	0.1
2	22	8	0	636	638	636	290	206	20.5	0.0	6.6	2.9	1616.6	0.1

2	22	8	1	637	638	638	291	208	20.5	0.0	7.3	3.0	1649.5	0.1
2	22	8	2	636	638	639	292	209	20.5	0.0	8.1	2.9	1697.5	0.1
2	22	8	3	637	637	639	292	210	20.5	0.0	7.3	2.9	1703.8	0.1
2	22	8	4	637	638	640	293	211	20.5	0.0	7.2	2.9	1731.8	0.1
2	22	8	5	638	639	640	293	212	20.5	0.0	7.3	3.0	1755.7	0.1
2	22	8	6	637	637	641	295	212	20.5	0.0	6.8	2.9	1815.4	0.1
2	22	8	7	637	638	640	301	213	20.5	0.0	6.6	2.9	1826.5	0.1
2	22	8	8	638	638	640	300	214	20.5	0.0	7.5	2.8	1731.0	0.1
2	22	8	9	638	639	640	302	215	20.5	0.0	5.1	3.0	1685.4	0.1
2	22	8	10	637	637	640	303	217	20.5	0.0	4.6	2.8	1685.9	0.1
2	22	8	11	636	637	640	302	218	20.5	0.0	6.1	2.7	1735.0	0.1
2	22	8	12	637	636	639	302	218	20.5	0.0	7.4	2.6	1750.1	0.1
2	22	8	13	636	636	639	302	219	20.5	0.0	6.6	2.7	1790.0	0.1
2	22	8	14	635	635	639	302	220	20.5	0.0	6.6	3.0	1822.9	0.1
2	22	8	15	635	635	639	302	220	20.5	0.0	7.0	2.8	1831.5	0.1
2	22	8	16	636	636	640	304	221	20.5	0.0	7.0	3.0	1882.8	0.1
2	22	8	17	634	636	638	308	221	20.5	0.0	5.8	2.9	1803.7	0.1
2	22	8	18	639	639	642	309	222	20.5	0.0	5.7	3.1	1768.0	0.1
2	22	8	19	639	639	643	308	223	20.5	0.0	5.6	3.0	1777.0	0.1
2	22	8	20	639	640	644	308	224	20.5	0.0	5.6	2.9	1789.6	0.1
2	22	8	21	643	643	648	310	225	20.5	0.0	6.0	3.1	1838.0	0.1
2	22	8	22	645	644	649	308	225	20.5	0.0	6.9	3.0	1869.8	0.1
2	22	8	23	648	648	650	309	226	20.5	0.0	6.9	2.9	1909.4	0.1
2	22	8	24	648	649	652	307	226	20.5	0.0	6.3	2.9	1924.2	0.1
2	22	8	25	650	651	652	311	226	20.5	0.0	6.8	2.8	1939.2	0.1
2	22	8	26	651	651	653	315	227	20.5	0.0	5.3	3.3	1876.9	0.1
2	22	8	27	651	651	654	314	227	20.5	0.0	4.2	3.6	1840.7	0.1
2	22	8	28	651	651	652	315	228	20.5	0.0	4.5	2.8	1810.2	0.1
2	22	8	29	650	650	652	315	229	20.5	0.0	4.3	3.0	1813.7	0.1
2	22	8	30	649	649	652	316	229	20.5	0.0	4.9	2.6	1817.0	0.1
2	22	8	31	649	650	653	314	230	20.5	0.0	4.8	2.6	1829.1	0.1
2	22	8	32	648	649	653	314	230	20.5	0.0	4.7	3.0	1875.7	0.1
2	22	8	33	647	647	652	315	231	20.5	0.0	5.5	3.0	1915.4	0.1
2	22	8	34	647	648	653	313	231	20.5	0.0	4.9	3.2	1946.0	0.1
2	22	8	35	649	650	653	316	230	20.5	0.0	4.6	3.0	1947.5	0.1
2	22	8	36	649	649	652	317	231	20.5	0.0	3.8	2.8	1873.4	0.1
2	22	8	37	648	649	652	310	232	20.5	0.0	3.5	2.7	1833.7	0.1
2	22	8	38	648	648	653	304	233	20.5	0.0	3.3	3.0	1816.0	0.1
2	22	8	39	646	647	651	297	234	20.5	0.0	3.8	2.8	1827.8	0.1
2	22	8	40	646	646	652	291	234	20.5	0.0	3.8	2.6	1836.2	0.1
2	22	8	41	645	645	652	285	234	20.5	0.0	4.5	2.7	1863.8	0.1
2	22	8	42	645	646	652	280	235	20.5	0.0	5.1	3.0	1901.8	0.1
2	22	8	43	644	645	652	274	235	20.5	0.0	4.5	2.9	1885.9	0.1
2	22	8	44	645	645	652	269	235	20.5	0.0	5.3	3.0	1934.6	0.1
2	22	8	45	646	646	651	266	235	20.5	0.0	3.2	3.0	1881.5	0.1
2	22	8	46	646	647	652	263	236	20.5	0.0	2.8	3.5	1819.1	0.1
2	22	8	47	646	647	651	261	236	20.5	0.0	3.4	2.5	1797.4	0.1
2	22	8	48	646	646	651	258	237	20.5	0.0	3.0	2.8	1812.0	0.1
2	22	8	49	647	648	652	254	237	20.5	0.0	2.7	2.8	1844.2	0.1
2	22	8	50	648	648	652	253	238	20.5	0.0	3.2	3.0	1889.4	0.1
2	22	8	51	648	648	650	250	238	20.5	0.0	3.5	3.1	1895.3	0.1
2	22	8	52	648	648	651	247	238	20.5	0.0	3.1	3.1	1939.2	0.1
2	22	8	53	652	651	652	245	237	20.5	0.0	3.9	3.1	1976.9	0.1
2	22	8	54	653	653	651	242	238	20.5	0.0	3.0	3.4	1934.5	0.1
2	22	8	55	653	652	649	239	238	20.5	0.0	2.4	2.9	1864.8	0.1
2	22	8	56	654	654	649	237	239	20.5	0.0	2.4	2.9	1855.6	0.1
2	22	8	57	654	655	649	324	240	20.5	0.0	2.7	2.7	1866.5	0.1
2	22	8	58	655	655	649	320	239	20.5	0.0	3.6	2.7	1908.6	0.1
2	22	8	59	654	654	648	320	239	20.5	0.0	3.9	3.1	1940.6	0.1
2	22	9	0	653	653	646	318	239	20.5	0.0	3.1	3.2	1954.8	0.1
2	22	9	1	655	654	647	319	239	20.5	0.0	3.9	3.1	1975.6	0.1
2	22	9	2	656	656	645	320	239	20.5	0.0	6.8	3.1	2002.3	0.1
2	22	9	3	655	657	645	322	239	20.5	0.0	3.6	2.9	1929.5	0.1
2	22	9	4	657	657	642	321	239	20.5	0.0	2.6	2.7	1888.1	0.1
2	22	9	5	658	658	643	322	240	20.5	0.0	2.9	3.1	1867.0	0.1
2	22	9	6	658	658	642	321	240	20.5	0.0	3.0	3.1	1879.8	0.1
2	22	9	7	656	656	641	319	240	20.5	0.0	3.3	3.1	1932.0	0.1

2	22	9	8	656	656	640	319	240	20.5	0.0	4.8	3.4	1947.9	0.1
2	22	9	9	653	653	640	317	240	20.5	0.0	6.7	3.4	1947.9	0.1
2	22	9	10	652	652	640	319	239	20.5	0.0	6.9	3.2	1981.6	0.1
2	22	9	11	651	651	640	319	239	20.5	0.0	5.6	3.0	1958.6	0.1
2	22	9	12	650	650	641	322	240	20.5	0.0	5.9	2.8	1874.6	0.1
2	22	9	13	647	647	640	321	240	20.5	0.0	4.1	2.8	1822.7	0.1
2	22	9	14	645	646	640	321	240	20.5	0.0	4.9	2.8	1848.5	0.1
2	22	9	15	645	645	640	321	240	20.5	0.0	4.5	2.9	1868.1	0.1
2	22	9	16	643	643	640	320	240	20.5	0.0	4.9	2.9	1902.0	0.1
2	22	9	17	641	641	641	319	240	20.5	0.0	5.1	2.7	1910.8	0.1
2	22	9	18	644	644	641	321	240	20.5	0.0	5.8	3.0	1933.4	0.1
2	22	9	19	643	644	641	325	240	20.5	0.0	6.5	3.1	1907.0	0.1
2	22	9	20	645	645	641	331	241	20.5	0.0	4.4	3.2	1821.2	0.1
2	22	9	21	643	644	641	332	242	20.5	0.0	111.2	3.3	1765.3	0.1
2	22	9	22	642	644	643	333	243	20.5	0.0	8.8	2.3	1712.3	0.1
2	22	9	23	642	643	646	334	244	20.5	0.0	3.5	2.7	1695.7	0.1
2	22	9	24	635	637	644	333	244	20.5	0.0	5.2	2.8	1695.4	0.1
2	22	9	25	634	635	644	333	245	20.5	0.0	4.5	2.8	1703.5	0.1
2	22	9	26	632	633	644	331	245	20.5	0.0	5.3	2.8	1748.8	0.1
2	22	9	27	630	631	644	332	245	20.5	0.0	5.7	3.1	1793.0	0.1
2	22	9	28	635	636	646	338	246	20.5	0.0	4.6	3.0	1805.0	0.1
2	22	9	29	635	637	647	339	247	20.5	0.0	2.8	3.3	1721.8	0.1
2	22	9	30	637	638	648	339	247	20.5	0.0	3.7	2.4	1672.3	0.1
Average Base Case 1				**645**	**645**	**646**	**304**	**232**	**20.5**	**0.0**	**6**	**3**	**1840**	**0**
2	22	9	31	641	642	649	339	248	20.5	0.0	20.2	2.6	1605.7	9.0
2	22	9	32	644	645	651	339	248	19.9	0.6	426.7	2.9	1861.8	9.0
2	22	9	33	646	646	652	338	249	19.9	0.8	456.4	2.7	1863.1	8.0
2	22	9	34	646	647	653	335	249	19.8	0.9	466.7	2.9	1860.9	5.8
2	22	9	35	648	649	652	338	249	19.8	0.9	509.8	2.8	1883.1	5.8
2	22	9	36	651	652	653	343	250	19.8	0.9	444.4	3.3	1837.5	5.0
2	22	9	37	651	653	653	344	250	19.9	0.8	389.2	2.9	1788.5	5.0
2	22	9	38	650	651	653	344	251	19.9	0.8	392.0	2.9	1772.4	5.8
2	22	9	39	647	651	653	343	251	19.9	0.8	406.1	3.0	1770.5	9.9
2	22	9	40	651	652	653	342	252	19.8	0.9	450.2	2.6	1791.6	4.0
2	22	9	41	650	652	653	341	252	19.9	0.8	401.9	2.4	1752.9	4.0
2	22	9	42	650	651	654	340	252	19.8	0.9	461.4	2.6	1793.9	5.0
2	22	9	43	650	651	654	342	251	19.8	0.9	437.1	2.5	1769.8	5.7
2	22	9	44	652	653	655	346	252	19.8	0.9	434.1	2.7	1777.4	4.8
2	22	9	45	650	652	655	345	253	19.9	0.8	395.5	2.5	1752.7	4.9
2	22	9	46	650	652	654	345	253	19.8	0.9	491.2	2.6	1813.5	5.0
2	22	9	47	651	652	655	344	253	19.9	0.8	388.1	2.5	1742.1	5.0
2	22	9	48	650	651	655	343	253	19.9	0.8	398.8	2.7	1721.3	4.1
2	22	9	49	650	650	655	341	253	19.8	0.9	400.3	3.1	1737.6	4.0
2	22	9	50	649	650	656	342	253	19.8	0.9	425.8	2.4	1750.6	4.4
2	22	9	51	651	652	655	344	253	19.8	0.9	463.2	2.7	1796.6	4.0
2	22	9	52	655	656	654	344	253	19.8	0.8	560.3	2.6	1845.7	0.1
2	22	9	53	658	659	654	346	253	20.2	0.5	244.7	2.6	1209.8	5.0
2	22	9	54	655	655	654	344	254	19.9	0.7	364.5	2.4	1476.5	5.7
2	22	9	55	655	655	655	343	254	19.8	0.8	429.1	2.3	1647.9	3.0
2	22	9	56	652	653	654	342	254	19.9	0.8	379.8	2.9	1680.6	3.2
2	22	9	57	650	651	655	341	254	19.8	0.8	418.0	2.7	1731.9	4.0
2	22	9	58	651	651	654	339	253	19.8	0.9	450.8	2.2	1767.1	5.0
2	22	9	59	652	653	656	344	254	19.8	0.9	435.6	2.6	1764.3	41.5
2	22	10	0	651	653	656	346	254	19.5	1.4	843.5	2.9	1846.9	3.0
2	22	10	1	651	653	654	346	254	19.8	0.9	502.1	2.8	1657.6	3.9
2	22	10	2	651	652	655	346	255	19.8	0.9	464.0	2.2	1659.9	3.0
2	22	10	3	648	649	656	345	255	19.8	0.9	428.4	2.8	1656.6	4.0
2	22	10	4	649	649	655	342	255	19.7	1.0	429.7	2.3	1706.5	5.0
2	22	10	5	649	649	656	340	255	19.7	1.0	430.3	2.7	1734.3	5.0
2	22	10	6	650	651	656	343	254	19.7	1.0	432.2	2.4	1760.7	5.1
2	22	10	7	653	653	655	347	254	19.8	0.9	418.2	2.1	1779.7	4.0
2	22	10	8	651	653	655	346	255	19.8	0.8	411.0	2.4	1781.4	11.7
2	22	10	9	650	651	655	346	255	19.8	0.9	477.8	2.8	1844.9	5.0
2	22	10	10	651	653	655	344	255	19.8	0.9	438.0	2.9	1816.5	5.0
2	22	10	11	651	650	655	344	255	19.6	1.0	558.2	3.0	1902.3	4.0
2	22	10	12	650	652	655	342	255	19.7	1.0	499.3	3.0	1875.4	5.0
2	22	10	13	651	652	656	341	255	19.7	1.0	448.2	2.3	1850.0	4.0

2	22	10	14	651	652	656	342	254	19.7	0.9	433.8	2.9	1851.8	8.0
2	22	10	15	652	654	656	346	255	19.4	1.6	869.6	2.6	1849.6	4.0
2	22	10	16	652	653	655	346	255	19.6	1.1	641.8	2.8	1717.1	4.0
2	22	10	17	652	655	656	346	256	19.6	1.1	593.4	2.4	1701.0	4.0
2	22	10	18	653	655	656	344	256	19.6	1.0	537.3	2.3	1686.6	2.1
2	22	10	19	652	654	656	343	256	19.5	1.1	562.0	2.5	1745.8	2.0
2	22	10	20	651	653	655	342	256	19.8	0.9	404.3	2.8	1630.9	5.0
2	22	10	21	651	653	656	340	255	19.6	1.1	448.7	2.1	1680.0	6.6
2	22	10	22	653	654	655	343	255	19.7	1.1	467.8	2.5	1726.6	4.0
2	22	10	23	653	654	655	347	255	19.8	0.9	368.7	2.6	1688.6	4.0
2	22	10	24	651	653	655	347	256	19.8	0.9	364.3	2.4	1696.3	6.8
2	22	10	25	652	654	655	345	256	19.8	0.9	391.9	2.8	1727.7	4.3
2	22	10	26	652	653	655	345	256	19.8	0.9	390.0	2.5	1738.7	4.0
2	22	10	27	650	650	655	344	256	19.8	1.0	403.4	2.5	1760.1	4.0
2	22	10	28	651	652	656	341	256	19.7	1.0	444.4	2.6	1803.6	5.0
2	22	10	29	651	652	656	341	255	19.7	1.1	454.3	2.7	1808.8	4.0
2	22	10	30	652	653	655	344	255	19.7	1.1	450.6	2.6	1814.7	5.9
2	22	10	31	652	654	655	344	255	19.8	1.0	435.3	2.7	1825.9	5.8
2	22	10	32	653	655	655	346	256	19.8	0.9	424.8	2.7	1811.1	3.3
2	22	10	33	652	653	655	345	256	19.8	0.9	403.7	2.3	1785.1	4.0
2	22	10	34	652	652	655	344	256	19.8	1.0	438.1	2.5	1820.1	5.0
2	22	10	35	652	651	656	342	255	19.7	1.0	470.4	2.5	1860.0	5.8
2	22	10	36	651	652	656	341	255	19.7	1.0	453.9	2.9	1848.5	4.0
2	22	10	37	651	652	656	341	255	19.3	1.1	779.3	3.1	2009.4	4.0
2	22	10	38	652	653	656	345	255	19.7	1.1	466.3	2.9	1888.9	7.9
2	22	10	39	653	654	656	345	255	19.3	1.5	1010.6	3.1	2077.7	4.0
2	22	10	40	652	654	656	346	255	19.6	1.1	709.4	2.6	1777.7	4.0
2	22	10	41	651	653	656	345	256	19.6	1.1	647.1	2.7	1732.8	3.9
2	22	10	42	653	654	656	343	256	19.6	1.1	561.3	2.6	1696.0	3.0
2	22	10	43	653	656	658	342	255	19.6	1.1	544.5	2.8	1691.6	3.0
2	22	10	44	653	654	657	340	255	19.6	1.1	508.3	2.6	1686.1	3.0
2	22	10	45	654	655	655	342	255	19.6	1.2	470.0	2.4	1682.7	5.8
2	22	10	46	656	657	656	346	255	19.7	1.1	433.6	2.8	1726.8	4.3
2	22	10	47	655	656	655	345	255	19.8	0.9	402.5	2.5	1734.0	5.0
2	22	10	48	655	656	655	344	256	19.8	0.9	390.6	2.5	1726.3	4.7
2	22	10	49	653	655	655	344	256	19.7	1.0	419.3	2.5	1757.6	4.0
2	22	10	50	654	655	656	342	255	19.7	1.0	435.7	2.6	1794.2	4.0
2	22	10	51	654	655	657	341	255	19.7	1.0	434.1	2.5	1800.9	4.0
2	22	10	52	653	655	655	341	255	19.7	1.1	434.2	2.8	1793.9	5.0
2	22	10	53	655	656	655	343	255	19.6	1.1	463.6	2.1	1819.5	5.0
2	22	10	54	656	657	655	345	255	19.7	1.0	443.7	2.6	1814.8	4.3
2	22	10	55	655	656	655	346	255	19.8	0.9	393.8	2.7	1781.0	5.8
2	22	10	56	653	654	655	345	256	19.8	0.9	435.0	2.6	1812.1	4.0
2	22	10	57	653	653	655	343	256	19.8	0.9	406.5	3.2	1798.1	3.9
2	22	10	58	654	655	654	342	256	19.8	0.9	410.9	2.7	1800.4	5.9
2	22	10	59	653	654	656	341	255	19.7	1.1	537.2	2.4	1897.9	5.8
Average Case Case 2				**651**	**653**	**655**	**343**	**254**	**19.8**	**0.9**	**464**	**3**	**1768**	**5**
2	22	11	0	653	652	656	343	255	19.7	1.0	461.7	2.8	1883.8	4.0
2	22	11	1	656	655	657	345	255	19.7	1.0	489.4	3.1	1893.4	4.0
2	22	11	2	660	662	661	347	256	19.4	0.9	661.1	2.7	1910.9	2.2
2	22	11	3	665	666	666	347	256	19.5	1.2	734.9	2.7	1738.7	1.8
2	22	11	4	668	669	668	347	256	19.6	1.1	627.0	2.5	1661.9	1.1
2	22	11	5	670	672	670	346	256	19.6	1.1	569.9	2.3	1628.2	0.7
2	22	11	6	676	677	674	344	256	19.5	1.1	513.9	2.6	1620.3	0.1
2	22	11	7	683	685	680	344	256	19.6	1.2	419.0	2.5	1638.9	0.1
2	22	11	8	688	690	682	348	256	19.5	1.2	417.4	2.5	1660.9	0.1
2	22	11	9	693	694	683	351	256	19.7	1.0	360.7	2.3	1669.1	1.1
2	22	11	10	693	695	683	351	257	19.8	0.9	353.5	2.3	1693.1	0.1
2	22	11	11	693	694	685	352	257	19.8	0.9	325.4	2.6	1705.3	0.1
2	22	11	12	694	695	685	351	257	19.8	0.9	323.5	2.5	1714.7	0.1
2	22	11	13	695	696	685	350	257	19.7	1.0	344.4	2.6	1718.6	0.1
2	22	11	14	697	698	686	349	257	19.7	1.0	357.6	2.7	1751.7	0.1
2	22	11	15	697	700	686	349	257	19.7	1.1	344.8	2.9	1793.4	0.1
Start Test 1														
2	22	11	16	700	702	686	353	257	19.7	1.1	366.0	2.8	1821.8	0.1
2	22	11	17	701	703	685	354	257	19.7	1.0	357.2	2.5	1797.6	0.1
2	22	11	18	703	705	685	354	258	19.8	0.9	330.8	2.7	1785.1	0.1

2	22	11	19	701	704	685	353	258	19.8	0.9	324.7	2.7	1783.5	0.1
2	22	11	20	703	704	685	351	258	19.7	1.0	352.4	2.9	1809.7	0.1
2	22	11	21	702	704	684	350	258	19.7	1.0	375.8	2.7	1844.7	0.1
2	22	11	22	704	706	684	349	258	19.6	1.0	368.0	2.7	1846.6	0.1
2	22	11	23	704	706	684	351	258	19.7	1.1	353.4	2.8	1873.6	0.1
2	22	11	24	706	707	683	355	258	19.7	1.0	347.5	2.8	1879.4	0.1
2	22	11	25	708	708	683	355	259	19.8	0.9	351.3	3.1	1858.4	0.1
2	22	11	26	708	710	683	354	259	19.8	0.8	330.8	2.8	1857.3	0.1
2	22	11	27	708	709	683	350	259	19.7	0.9	349.7	3.0	1874.1	0.1
2	22	11	28	707	710	682	350	259	19.6	1.1	390.0	3.1	1958.2	0.1
2	22	11	29	704	709	681	353	259	19.8	1.0	375.5	3.0	1941.1	0.1
2	22	11	30	677	683	679	356	259	19.8	0.9	380.5	2.8	1926.5	0.1
2	22	11	31	669	670	680	356	259	19.6	0.8	546.7	2.6	1934.7	0.1
2	22	11	32	691	692	680	353	260	19.5	1.3	753.3	2.6	1739.8	0.1
2	22	11	33	698	699	679	351	260	19.5	1.1	678.9	2.9	1735.6	0.1
2	22	11	34	685	688	679	352	259	19.5	1.2	634.4	2.6	1723.4	0.1
2	22	11	35	679	681	678	353	259	19.6	1.1	567.9	2.7	1698.5	1.1
2	22	11	36	694	695	677	356	259	19.7	1.1	423.8	2.7	1713.5	1.1
2	22	11	37	694	697	676	357	260	19.8	0.9	359.2	2.6	1732.9	1.1
2	22	11	38	683	684	676	358	261	19.8	0.8	356.7	2.7	1763.0	1.1
2	22	11	39	679	680	675	356	261	19.8	0.8	384.7	2.9	1755.5	2.0
2	22	11	40	688	689	676	355	261	19.8	0.9	372.1	2.6	1749.4	1.1
2	22	11	41	689	690	676	353	261	19.8	0.9	377.0	2.6	1767.1	1.1
2	22	11	42	690	691	677	352	260	19.7	1.0	393.6	2.6	1788.5	0.2
2	22	11	43	692	694	677	355	260	19.7	1.1	414.6	2.8	1805.5	1.1
2	22	11	44	692	694	677	358	261	19.8	0.9	378.1	2.8	1782.4	1.1
2	22	11	45	691	692	675	358	261	19.8	0.9	374.9	2.3	1783.1	1.1
2	22	11	46	689	690	677	358	262	19.8	0.8	378.9	2.7	1786.3	1.2
2	22	11	47	686	687	678	356	262	19.8	0.9	393.6	2.9	1800.6	0.1
2	22	11	48	685	687	678	356	262	19.8	0.9	378.6	2.6	1779.2	1.1
2	22	11	49	683	684	679	354	261	19.7	1.0	394.7	2.7	1792.8	1.1
2	22	11	50	682	683	679	354	261	19.7	1.0	410.2	2.6	1800.7	1.1
2	22	11	51	685	686	680	358	261	19.7	1.0	398.1	2.5	1793.6	1.1
2	22	11	52	683	684	679	360	262	19.8	0.8	374.5	2.8	1778.6	0.1
2	22	11	53	684	686	681	360	262	19.7	1.1	629.7	2.6	1683.7	0.1
2	22	11	54	686	687	683	360	263	19.7	1.0	560.2	2.3	1668.9	0.1
2	22	11	55	685	686	684	358	262	19.7	1.0	502.9	2.4	1644.3	0.1
2	22	11	56	685	687	685	356	262	19.7	1.0	444.5	2.4	1650.0	0.1
2	22	11	57	685	687	685	354	262	19.6	1.1	417.0	2.3	1682.3	0.1
2	22	11	58	688	688	684	357	262	19.7	1.0	394.6	2.5	1728.9	0.2
2	22	11	59	691	693	685	361	262	19.8	0.9	364.1	2.6	1707.2	0.1
2	22	12	0	691	693	685	361	263	19.9	0.8	342.7	2.5	1697.8	0.1
2	22	12	1	689	690	685	360	263	19.9	0.8	317.5	2.6	1700.6	0.1
2	22	12	2	688	689	684	359	263	19.8	0.9	345.1	2.8	1708.7	0.1
2	22	12	3	688	689	686	357	263	19.8	0.9	371.2	3.0	1728.9	0.1
2	22	12	4	688	689	686	356	263	19.8	1.0	352.9	2.8	1729.5	0.1
2	22	12	5	690	692	686	357	262	19.7	1.0	361.7	2.5	1741.8	0.1
2	22	12	6	693	696	687	361	262	19.7	1.0	363.7	3.0	1755.2	0.1
2	22	12	7	695	697	688	361	263	19.8	0.8	337.1	3.1	1742.6	0.1
2	22	12	8	695	697	689	360	263	19.8	0.8	353.9	2.6	1766.4	0.1
2	22	12	9	693	694	690	360	263	19.8	0.8	332.1	2.9	1755.1	0.1
2	22	12	10	687	688	689	359	263	19.8	0.9	352.7	2.7	1762.9	0.1
2	22	12	11	686	687	690	356	263	19.8	0.9	355.2	2.6	1752.5	0.1
2	22	12	12	687	688	691	359	263	19.7	0.9	352.4	2.5	1771.9	0.1
2	22	12	13	687	689	690	361	263	19.8	0.9	355.1	2.9	1789.4	0.1
2	22	12	14	688	689	690	363	264	19.7	1.0	585.9	2.7	1688.6	0.1
2	22	12	15	689	691	690	362	264	19.7	0.9	544.0	2.8	1652.8	0.1
Average Test 1				691	693	683	356	261	19.7	1.0	407	3	1773	0
2	22	12	16	690	692	692	362	264	19.7	0.9	482.0	2.4	1627.0	0.1
2	22	12	17	689	690	693	361	264	19.7	0.9	395.7	2.3	1593.8	0.1
2	22	12	18	693	695	696	361	264	19.7	1.0	356.4	2.5	1640.8	0.1
2	22	12	19	700	701	700	365	264	19.8	0.9	310.8	2.7	1669.4	0.1
2	22	12	20	706	708	706	367	265	19.8	0.9	290.8	2.6	1700.5	0.1
2	22	12	21	711	714	712	366	265	19.8	0.9	283.8	3.2	1710.0	0.1
2	22	12	22	711	716	716	366	266	19.8	0.9	268.9	2.8	1732.7	0.1
2	22	12	23	667	674	719	369	266	19.8	0.9	255.5	3.1	1740.8	0.1
2	22	12	24	688	688	720	366	266	19.7	1.0	279.9	2.6	1652.3	0.1

2	22	12	25	704	707	722	365	265	19.7	1.0	276.5	2.9	1726.0	0.1
2	22	12	26	713	715	724	367	265	19.6	1.1	278.0	2.7	1788.2	0.1
2	22	12	27	718	720	723	371	266	19.8	0.9	260.9	3.1	1802.8	0.1
2	22	12	28	715	721	725	373	266	19.8	0.9	258.5	3.1	1806.5	0.1
2	22	12	29	683	685	726	373	267	19.8	0.8	280.2	2.8	1767.9	0.1
2	22	12	30	707	708	726	372	267	19.7	0.9	277.8	2.9	1743.3	0.1
2	22	12	31	715	717	727	371	267	19.8	0.9	247.3	2.8	1782.1	0.1
2	22	12	32	719	720	728	370	267	19.7	1.0	246.2	3.1	1838.6	0.1
2	22	12	33	721	722	727	367	266	19.7	1.0	254.0	3.0	1870.6	0.1
2	22	12	34	728	730	730	372	267	19.7	1.0	247.9	2.9	1882.1	0.1
2	22	12	35	731	731	729	375	267	19.8	0.9	258.3	3.3	1891.2	0.1
2	22	12	36	732	734	733	377	268	19.8	0.8	248.8	2.9	1891.0	0.1
2	22	12	37	736	738	735	377	268	19.8	0.8	233.0	2.9	1895.6	0.1
2	22	12	38	739	741	739	377	269	19.8	0.9	211.6	2.8	1913.2	0.1
2	22	12	39	739	739	742	375	269	19.7	0.9	217.3	3.3	1945.6	0.1
2	22	12	40	740	741	744	374	268	19.8	0.9	178.5	2.9	1934.5	0.1
2	22	12	41	742	744	747	373	268	19.7	1.0	208.8	3.2	2007.5	0.1
2	22	12	42	742	744	745	377	268	19.8	1.0	177.7	3.2	2000.8	0.1
2	22	12	43	739	741	746	380	269	19.8	0.9	195.0	3.7	1988.1	0.1
2	22	12	44	740	741	745	380	270	19.8	0.9	258.9	2.7	2012.0	0.1
2	22	12	45	744	745	747	380	270	19.9	0.8	209.3	3.5	1997.0	0.1
Start Test 2														
2	22	12	46	745	745	749	380	270	19.8	0.8	214.1	3.3	2021.5	0.1
2	22	12	47	747	747	749	379	270	19.7	0.9	243.2	3.1	2077.2	0.1
2	22	12	48	747	748	751	377	270	19.8	0.9	198.9	3.4	2060.5	0.1
2	22	12	49	748	749	751	378	269	19.6	1.0	250.7	3.1	2140.9	0.1
2	22	12	50	747	749	752	381	270	19.3	0.9	463.9	3.4	2104.1	0.1
2	22	12	51	747	750	751	383	270	19.4	1.3	440.5	3.3	1995.7	0.1
2	22	12	52	748	750	751	383	271	19.6	1.1	355.5	2.6	1935.5	0.1
2	22	12	53	748	750	751	382	271	19.6	1.1	295.9	3.2	1911.0	0.1
2	22	12	54	747	750	751	381	271	19.6	1.0	225.6	3.3	1971.3	0.1
2	22	12	55	748	750	752	379	271	19.6	1.0	230.3	3.0	1984.4	0.1
2	22	12	56	751	753	751	379	270	19.6	1.0	209.6	3.4	2024.4	0.1
2	22	12	57	751	754	750	383	271	19.7	1.0	205.2	3.6	2068.9	0.1
2	22	12	58	738	739	750	385	271	19.8	0.9	197.2	3.4	2020.8	0.1
2	22	12	59	744	747	750	384	272	19.8	0.9	222.2	3.4	2001.8	0.1
2	22	13	0	747	749	750	382	272	19.8	0.9	204.5	3.3	2017.9	0.1
2	22	13	1	747	749	750	382	272	19.7	0.9	205.0	3.6	2049.0	0.1
2	22	13	2	748	751	750	380	271	19.7	1.0	201.2	3.4	2040.0	0.1
2	22	13	3	731	733	750	377	271	19.6	1.0	204.3	3.1	2071.1	0.1
2	22	13	4	739	741	751	376	270	19.6	1.1	216.3	3.4	2064.9	0.1
2	22	13	5	745	747	749	380	271	19.6	1.1	223.2	3.7	2090.8	0.1
2	22	13	6	741	743	747	382	271	19.8	0.9	222.4	3.3	2063.8	0.1
2	22	13	7	745	748	748	382	271	19.7	0.9	242.1	3.3	2063.7	0.1
2	22	13	8	746	748	748	380	271	19.7	0.9	231.7	3.5	2054.2	0.1
2	22	13	9	743	745	748	380	271	19.7	0.9	233.1	3.3	2075.6	0.1
2	22	13	10	726	729	748	379	271	19.7	1.0	240.6	3.4	2067.8	0.1
2	22	13	11	727	730	748	377	271	19.7	1.0	247.8	3.4	2055.8	0.1
2	22	13	12	734	737	748	376	270	19.6	1.0	238.6	3.7	2074.5	0.1
2	22	13	13	737	740	748	378	270	19.6	1.0	264.6	3.7	2081.4	0.1
2	22	13	14	738	742	745	380	271	19.6	1.1	425.0	3.3	2017.4	0.1
2	22	13	15	742	744	745	380	271	19.7	1.0	378.2	3.4	1997.1	0.1
Average Test 2				**743**	**745**	**749**	**380**	**271**	**19.7**	**1.0**	**258**	**3**	**2040**	**0**
2	22	13	16	741	744	745	378	271	19.6	1.0	306.3	3.2	1961.3	0.1
2	22	13	17	742	743	748	378	271	19.8	0.9	230.1	3.2	2016.7	0.1
2	22	13	18	744	747	749	377	271	19.9	0.8	168.5	3.2	1963.1	0.1
2	22	13	19	748	751	753	377	270	20.0	0.7	131.3	3.0	1952.0	0.1
2	22	13	20	749	752	755	378	270	20.0	0.7	130.1	3.3	1916.9	0.1
2	22	13	21	718	722	756	384	271	20.1	0.6	121.8	2.8	1891.7	0.1
2	22	13	22	711	713	758	385	272	20.0	0.6	226.6	3.2	1903.9	0.1
2	22	13	23	722	724	758	384	272	20.0	0.6	189.6	3.2	1884.7	0.1
2	22	13	24	731	733	759	382	272	20.0	0.6	183.6	3.1	1910.9	0.1
2	22	13	25	737	740	761	380	272	20.0	0.7	183.5	2.8	1947.6	0.1
2	22	13	26	725	730	764	382	272	19.9	0.7	183.7	3.2	1985.8	0.1
2	22	13	27	685	687	768	390	272	20.0	0.7	205.7	3.6	1941.0	0.1
2	22	13	28	679	679	771	389	273	20.0	0.6	196.7	2.9	1832.4	0.1
2	22	13	29	691	693	773	387	273	20.0	0.6	198.1	3.1	1800.9	0.1

2	22	13	30	704	707	775	385	273	20.0	0.7	203.1	2.9	1839.3	0.1
2	22	13	31	717	719	774	384	273	19.9	0.7	185.8	3.0	1883.0	0.1
2	22	13	32	707	709	772	387	273	20.0	0.7	183.3	3.2	1907.3	0.1
2	22	13	33	722	725	772	382	273	20.0	0.6	231.6	2.9	1889.4	0.1
2	22	13	34	699	710	771	389	274	20.0	0.6	194.5	3.3	1891.1	0.1
2	22	13	35	675	704	771	389	274	20.1	0.6	220.4	3.0	1809.6	0.1
2	22	13	36	664	693	771	387	274	20.0	0.6	181.2	2.7	1699.1	0.1
2	22	13	37	680	687	767	386	273	20.3	0.4	85.4	2.4	1210.9	0.1
2	22	13	38	701	703	758	387	273	20.5	0.1	40.3	1.5	871.4	0.1
2	22	13	39	697	698	741	379	273	20.5	0.0	33.3	1.8	722.2	0.1
2	22	13	40	721	722	729	374	271	20.5	0.0	23.7	1.6	624.1	0.1
2	22	13	41	718	720	722	371	270	20.6	0.0	11.2	1.0	571.0	0.1
2	22	13	42	721	727	713	369	268	20.6	0.0	11.5	1.5	507.5	0.1
2	22	13	43	627	537	645	364	267	20.6	-0.1	8.3	1.2	460.8	0.1
2	22	13	44	578	579	682	362	267	20.6	-0.1	36.6	0.9	424.8	0.1
2	22	13	45	613	614	689	360	266	20.6	-0.1	17.2	0.8	388.8	0.1
2	22	13	46	636	637	693	359	266	20.6	-0.1	15.9	1.0	358.1	0.1
2	22	13	47	654	654	697	357	265	20.6	-0.1	7.9	0.9	342.4	0.1
2	22	13	48	668	668	699	354	264	20.6	-0.1	7.3	1.0	321.1	0.1
2	22	13	49	679	680	700	353	264	20.6	-0.1	7.8	0.7	306.6	0.1
2	22	13	50	688	688	702	349	263	20.6	-0.1	8.4	0.8	289.3	0.1
2	22	13	51	696	696	702	351	262	20.6	-0.1	7.5	0.5	275.2	0.1
2	22	13	52	702	703	702	351	261	20.6	-0.1	6.1	0.6	264.6	0.1
2	22	13	53	707	708	702	351	261	20.6	-0.1	6.8	0.7	255.2	0.1
2	22	13	54	712	713	703	350	261	20.6	-0.1	7.2	0.6	245.0	0.1
2	22	13	55	717	718	706	349	260	20.6	-0.1	7.5	0.6	237.2	0.1
2	22	13	56	722	724	707	348	260	20.6	-0.1	8.5	0.7	228.1	0.1
2	22	13	57	726	726	707	349	259	20.6	-0.1	7.7	0.3	222.3	0.1
2	22	13	58	729	729	708	348	259	20.6	-0.1	9.0	0.5	217.0	0.1
2	22	13	59	731	732	708	348	258	20.6	-0.1	8.9	0.7	210.3	0.1
2	22	14	0	731	734	706	346	258	20.6	-0.1	10.4	0.8	204.9	0.1
2	22	14	1	736	737	708	343	257	20.6	-0.1	9.1	0.6	199.1	0.1
2	22	14	2	738	738	708	341	257	20.6	-0.1	8.6	0.6	194.4	0.1
2	22	14	3	740	741	708	343	256	20.6	-0.1	7.7	0.5	187.7	0.1
2	22	14	4	745	745	709	344	255	20.6	-0.1	6.1	0.7	183.5	0.1
2	22	14	5	745	746	700	336	257	20.6	-0.1	3.1	0.5	180.1	0.1
2	22	14	6	752	754	709	335	256	20.6	-0.1	12.0	0.7	176.2	0.1
2	22	14	7	757	758	708	328	256	20.6	-0.1	1.5	0.3	172.2	0.1
2	22	14	8	764	764	713	334	254	20.6	-0.1	1.7	0.4	168.4	0.1
2	22	14	9	767	767	720	337	252	20.6	-0.1	0.7	0.4	165.9	0.1
2	22	14	10	770	771	719	335	251	20.6	-0.1	0.8	0.7	159.4	0.1
2	22	14	11	771	772	718	336	250	20.6	0.0	2.8	0.3	169.3	0.1
2	22	14	12	772	773	717	337	250	20.6	0.0	0.6	0.6	159.6	0.1
2	22	14	13	769	769	714	336	249	20.6	0.0	0.6	0.3	156.4	0.1
2	22	14	14	762	763	710	336	249	20.6	0.0	6.7	0.3	155.9	0.1
2	22	14	15	757	758	707	336	249	20.6	-0.1	7.3	0.1	149.9	0.1
2	22	14	16	751	751	704	340	248	20.6	-0.1	6.4	0.6	147.6	0.1
2	22	14	17	744	744	701	342	249	20.6	-0.1	5.4	0.6	144.4	0.1
2	22	14	18	739	739	698	341	249	20.6	-0.1	6.4	0.5	141.1	0.1
2	22	14	19	736	736	695	333	249	20.6	-0.1	6.1	0.4	139.0	0.1
2	22	14	20	732	732	691	326	248	20.6	-0.1	6.3	0.6	136.9	0.1
2	22	14	21	727	727	691	319	248	20.6	-0.1	7.7	0.6	134.4	0.1
2	22	14	22	724	724	690	332	248	20.6	-0.1	9.9	0.4	133.8	0.1
2	22	14	23	731	732	694	323	248	20.6	-0.1	12.2	0.1	132.3	0.1
2	22	14	24	752	754	704	317	249	20.6	-0.1	3.7	0.3	131.0	0.1
2	22	14	25	774	778	717	314	249	20.6	-0.1	4.0	0.1	131.3	0.1
2	22	14	26	775	780	716	322	251	20.6	-0.1	0.4	0.3	128.1	0.1
2	22	14	27	753	774	723	316	248	20.6	-0.1	-0.1	0.4	126.5	0.1
2	22	14	28	737	768	723	311	245	20.6	-0.1	-1.4	0.4	121.9	0.1
2	22	14	29	723	758	733	313	244	20.6	-0.1	-1.4	0.1	122.0	0.1
2	22	14	30	709	749	743	332	244	20.6	-0.1	-1.3	0.4	118.9	0.1
2	22	14	31	696	740	749	334	244	20.6	-0.1	-1.5	0.4	117.8	0.1
2	22	14	32	684	730	752	354	244	20.6	-0.1	-2.0	0.4	115.5	0.1
2	22	14	33	670	720	749	354	244	20.6	-0.1	-1.4	0.4	114.6	0.1
2	22	14	34	658	711	739	356	244	20.6	-0.1	-1.4	0.4	112.7	0.1
2	22	14	35	650	701	729	354	244	20.6	-0.1	-1.7	0.3	112.1	0.1
2	22	14	35	637	691	721	353	243	20.6	-0.1	-1.8	0.4	111.6	0.1

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		ScanChannel		1	2	3	4	5	7.0	8.0	9.0	10.0	11.0	12.0
		Port.Channel		1001	1002	1003	1004	1005	1013.0	1014.0	1017.0	1018.0	1019.0	1020.0
		Chnl Tag		LowBed	MidBed	FRBRD	CycOut	BGHin	O2	CO2	Co ppm	So2ppm	Noxppm	THCppm
		Chnl Unit		C	C	C	C	C			PPM	PPM		PPM
Month	Day	Hour	Minute											
2	23	7	1	543	542	573	171	121	20.6	0.0	-6.4	0.2	14.9	0.1
2	23	7	2	570	569	582	177	124	20.5	0.0	-6.3	-0.4	14.6	0.1
2	23	7	3	592	592	588	190	126	20.6	0.0	-6.2	0.1	14.4	0.1
2	23	7	4	609	610	589	207	129	20.6	0.0	-6.3	-0.3	14.2	0.1
2	23	7	5	620	620	590	217	132	20.6	0.0	-5.7	0.1	14.2	0.1
2	23	7	6	628	628	589	223	136	20.6	0.0	-5.5	0.2	14.1	0.1
2	23	7	7	631	631	589	225	140	20.6	0.0	-5.5	0.1	14.5	0.1
2	23	7	8	635	635	590	230	144	20.6	0.0	-6.0	-0.2	13.9	0.1
2	23	7	9	638	638	589	232	147	20.6	0.0	-5.7	-0.1	14.5	0.1
2	23	7	10	637	639	589	233	150	20.5	0.0	-6.4	0.2	13.9	0.1
2	23	7	11	640	641	589	238	153	20.6	0.0	-5.9	0.3	14.2	0.1
2	23	7	12	640	641	589	249	155	20.6	0.0	-5.7	-0.4	14.1	0.1
2	23	7	13	640	640	588	256	158	20.6	0.0	-5.9	0.0	14.4	0.1
2	23	7	14	642	642	589	259	161	20.5	0.0	-5.2	0.1	14.2	0.1
2	23	7	15	641	642	588	261	164	20.6	0.0	-4.7	-0.1	14.3	0.1
2	23	7	16	640	641	587	261	167	20.5	0.0	-5.1	-0.1	13.8	0.1
2	23	7	17	642	642	588	261	170	20.6	0.0	-4.8	-0.2	14.3	0.1
2	23	7	18	641	642	589	261	172	20.6	0.0	-4.7	0.0	14.2	0.1
2	23	7	19	641	641	588	267	174	20.5	0.0	-4.8	-0.1	15.1	0.1
2	23	7	20	642	643	590	277	176	20.6	0.0	-5.3	0.1	14.6	0.1
2	23	7	21	641	642	589	278	179	20.5	0.0	-5.5	-0.1	14.0	0.1
2	23	7	22	641	642	589	281	181	20.6	0.0	-5.0	0.2	13.8	0.1
2	23	7	23	641	641	589	280	184	20.6	0.0	-4.8	0.0	14.4	0.1
2	23	7	24	640	641	589	278	186	20.5	0.0	-5.5	0.7	14.7	0.1
2	23	7	25	641	643	588	279	187	20.5	0.0	-1.9	0.2	31.3	0.1
2	23	7	26	642	642	588	278	189	20.5	0.0	-1.8	0.4	18.8	0.1
2	23	7	27	641	642	589	285	190	20.5	0.0	-2.4	0.4	17.7	0.1
2	23	7	28	642	642	590	291	192	20.5	0.0	-2.0	0.3	17.3	0.1
2	23	7	29	640	641	589	291	194	20.5	0.0	-2.1	0.6	17.4	0.1
2	23	7	30	641	642	590	291	196	20.5	0.0	-2.7	-0.1	16.9	0.1
2	23	7	31	641	642	590	291	198	20.5	0.0	-2.9	0.3	16.5	0.1
2	23	7	32	643	644	592	291	199	20.5	0.0	-2.8	0.1	16.9	0.1
2	23	7	33	645	646	593	290	201	20.5	0.0	-2.8	0.2	16.3	0.1
2	23	7	34	646	647	594	290	202	20.5	0.0	-2.9	0.1	16.8	0.1
2	23	7	35	647	648	594	297	203	20.5	0.0	-3.2	0.1	16.8	0.1
2	23	7	36	647	648	596	300	204	20.5	0.0	-2.7	0.0	17.0	0.1
2	23	7	37	646	647	595	299	206	20.5	0.0	-3.0	0.1	16.6	0.1
2	23	7	38	646	648	595	300	207	20.5	0.0	-3.0	-0.3	17.2	0.1
2	23	7	39	647	648	595	297	208	20.5	0.0	-3.0	0.3	17.0	0.1
2	23	7	40	647	648	594	298	209	20.5	0.0	-3.1	0.3	16.4	0.1
2	23	7	41	649	649	597	299	210	20.5	0.0	-3.1	0.0	16.5	0.1
2	23	7	42	644	646	595	305	211	20.5	0.0	-2.7	0.3	16.8	0.1
2	23	7	43	641	642	593	306	212	20.5	0.0	107.5	0.2	37.6	0.1
2	23	7	44	639	640	591	305	213	20.5	0.0	42.1	-0.1	29.7	0.1
2	23	7	45	636	637	588	302	214	20.5	0.0	8.0	0.4	22.0	0.1
2	23	7	46	636	636	588	300	215	20.5	0.0	5.0	0.2	21.2	0.1
2	23	7	47	637	637	589	298	216	20.5	0.0	5.9	0.2	24.1	0.1
2	23	7	48	634	635	587	300	216	20.5	0.0	5.2	-0.1	22.2	0.1
2	23	7	49	635	636	588	306	217	20.5	0.0	4.1	0.0	21.4	0.1
2	23	7	50	636	636	587	307	218	20.5	0.0	3.0	0.0	19.9	0.1
2	23	7	51	634	635	587	306	219	20.5	0.0	2.6	-0.1	19.7	0.1
2	23	7	52	633	633	587	310	220	20.5	0.0	21.0	0.5	224.8	0.1
2	23	7	53	629	630	588	310	221	20.5	0.0	14.9	1.2	589.4	0.1
2	23	7	54	626	627	587	309	222	20.5	0.0	12.1	1.4	766.8	0.1
2	23	7	55	626	626	588	307	223	20.5	0.0	10.3	1.5	933.9	0.1
2	23	7	56	629	629	589	311	223	20.5	0.0	9.7	1.9	1089.2	0.1
2	23	7	57	636	636	594	317	224	20.5	0.0	8.9	2.2	1180.1	0.1
2	23	7	58	640	641	596	321	226	20.5	0.0	7.4	2.1	1172.9	0.1
2	23	7	59	643	643	599	320	227	20.5	0.0	7.0	1.9	1227.2	0.1
Start Base Case 1														
2	23	8	0	646	646	602	320	228	20.5	0.0	6.9	2.0	1300.7	0.1
2	23	8	1	647	648	602	319	229	20.5	0.0	7.7	2.3	1362.2	0.1
2	23	8	2	647	647	602	319	230	20.5	0.0	7.9	2.4	1427.5	0.1

2	23	8	3	649	649	603	320	230	20.5	0.0	8.9	2.0	1488.6	0.1
2	23	8	4	649	649	603	332	231	20.5	0.0	8.7	2.0	1539.9	0.1
2	23	8	5	645	646	603	332	233	20.5	0.0	13.0	2.3	1425.9	0.1
2	23	8	6	643	644	605	334	235	20.5	0.0	8.9	2.1	1351.9	0.1
2	23	8	7	641	642	607	332	237	20.5	0.0	7.1	2.3	1384.7	0.1
2	23	8	8	639	640	609	333	238	20.5	0.0	7.0	2.4	1420.2	0.1
2	23	8	9	640	642	614	331	239	20.5	0.0	7.0	2.4	1481.2	0.1
2	23	8	10	641	643	619	331	239	20.5	0.0	7.5	2.4	1528.1	0.1
2	23	8	11	641	642	622	331	240	20.5	0.0	7.5	2.5	1579.2	0.1
2	23	8	11	643	643	624	339	241	20.5	0.0	7.2	2.3	1608.4	0.1
2	23	8	13	644	644	626	344	242	20.5	0.0	6.4	2.3	1522.4	0.1
2	23	8	14	642	643	628	341	244	20.5	0.0	5.8	2.4	1471.8	0.1
2	23	8	15	639	641	629	339	244	20.5	0.0	6.7	2.4	1511.4	0.1
2	23	8	15	640	640	632	338	245	20.5	0.0	6.9	2.2	1587.4	0.1
2	23	8	17	638	638	633	336	245	20.5	0.0	7.3	2.3	1637.0	0.1
2	23	8	18	641	642	636	334	245	20.5	0.0	7.2	2.6	1714.5	0.1
2	23	8	19	645	643	639	333	245	20.5	0.0	7.5	2.7	1772.4	0.1
2	23	8	20	645	645	640	333	245	20.5	0.0	7.2	2.7	1827.7	0.1
2	23	8	20	649	648	640	338	245	20.5	0.0	6.9	2.6	1832.3	0.1
2	23	8	21	648	650	640	339	246	20.5	0.0	6.1	2.3	1757.3	0.1
2	23	8	23	647	648	641	339	246	20.5	0.0	6.1	2.5	1721.8	0.1
2	23	8	23	646	647	640	339	247	20.5	0.0	6.3	2.3	1727.1	0.1
2	23	8	25	646	647	641	338	247	20.5	0.0	5.5	2.4	1747.8	0.1
2	23	8	25	645	646	641	337	247	20.5	0.0	6.3	2.7	1782.4	0.1
2	23	8	27	644	645	641	335	247	20.5	0.0	6.2	2.1	1828.8	0.1
2	23	8	27	645	646	641	335	247	20.5	0.0	5.6	2.6	1859.9	0.1
2	23	8	28	646	645	641	334	247	20.5	0.0	6.1	2.7	1895.0	0.1
2	23	8	29	647	648	641	339	247	20.5	0.0	5.6	2.6	1861.9	0.1
2	23	8	30	647	649	642	340	248	20.5	0.0	4.7	2.4	1798.9	0.1
2	23	8	31	646	647	640	339	248	20.5	0.0	5.3	2.3	1800.7	0.1
2	23	8	32	646	646	639	340	249	20.5	0.0	6.1	2.5	1795.3	0.1
2	23	8	33	646	646	639	337	249	20.5	0.0	5.2	2.6	1798.6	0.1
2	23	8	34	646	647	638	339	249	20.5	0.0	5.0	2.7	1803.1	0.1
2	23	8	35	646	647	640	338	249	20.5	0.0	5.3	2.4	1840.0	0.1
2	23	8	36	646	647	639	339	249	20.5	0.0	5.8	2.6	1865.3	0.1
2	23	8	37	648	649	638	343	250	20.5	0.0	5.1	2.5	1848.4	0.1
2	23	8	38	648	648	638	344	251	20.5	0.0	4.7	2.3	1770.3	0.1
2	23	8	39	646	647	637	344	251	20.5	0.0	4.6	2.9	1748.3	0.1
2	23	8	40	647	647	638	344	252	20.5	0.0	4.9	2.5	1753.9	0.1
2	23	8	41	646	647	638	343	252	20.5	0.0	5.2	2.6	1781.7	0.1
2	23	8	42	645	645	638	342	252	20.5	0.0	5.7	2.0	1805.1	0.1
2	23	8	43	644	644	637	339	252	20.5	0.0	5.6	2.7	1852.6	0.1
2	23	8	44	646	646	638	342	252	20.5	0.0	5.7	2.7	1877.2	0.1
2	23	8	45	647	646	636	346	252	20.5	0.0	5.0	2.5	1838.9	0.1
2	23	8	46	645	646	636	347	253	20.5	0.0	4.1	2.0	1772.4	0.1
2	23	8	47	645	646	636	346	253	20.5	0.0	4.4	2.7	1761.8	0.1
2	23	8	48	645	645	636	346	254	20.5	0.0	4.8	2.4	1775.2	0.1
2	23	8	49	643	644	635	344	254	20.5	0.0	4.7	2.8	1800.0	0.1
2	23	8	50	645	645	636	343	254	20.5	0.0	4.9	2.7	1832.6	0.1
2	23	8	51	644	645	634	341	254	20.5	0.0	5.1	2.7	1871.6	0.1
2	23	8	52	644	645	634	340	253	20.5	0.0	6.3	2.9	1905.2	0.1
2	23	8	53	648	648	635	346	254	20.5	0.0	5.5	2.5	1897.3	0.1
2	23	8	54	648	649	634	347	254	20.5	0.0	4.8	2.6	1818.1	0.1
2	23	8	55	647	647	632	347	255	20.5	0.0	4.9	2.1	1788.7	0.1
2	23	8	56	647	647	632	346	255	20.5	0.0	5.2	2.3	1790.7	0.1
2	23	8	57	648	648	631	345	255	20.5	0.0	5.3	2.1	1815.6	0.1
2	23	8	58	648	647	630	345	255	20.5	0.0	5.1	2.6	1835.2	0.1
2	23	8	59	649	649	628	344	255	20.5	0.0	4.9	2.7	1853.0	0.1
2	23	9	0	650	650	629	344	255	20.5	0.0	5.6	2.7	1882.3	0.1
2	23	9	1	648	649	627	347	255	20.5	0.0	5.6	2.3	1877.1	0.1
2	23	9	2	655	655	633	352	256	20.5	0.0	6.8	2.5	1802.4	0.1
2	23	9	3	651	651	635	353	257	20.5	0.0	5.8	2.3	1726.3	0.1
2	23	9	4	650	650	636	352	257	20.5	0.0	5.1	2.5	1695.5	0.1
2	23	9	5	645	646	636	349	257	20.5	0.0	5.2	2.5	1716.4	0.1
2	23	9	6	643	644	638	348	257	20.5	0.0	5.5	2.6	1766.8	0.1
2	23	9	7	642	642	639	346	257	20.5	0.0	6.2	2.5	1793.6	0.1
2	23	9	8	639	640	640	344	256	20.5	0.0	6.1	2.8	1845.4	0.1
2	23	9	9	640	640	640	347	256	20.5	0.0	6.3	2.2	1866.1	0.1
2	23	9	10	641	641	641	349	256	20.5	0.0	6.0	2.4	1819.6	0.1

2	23	9	11	640	641	641	352	257	20.5	0.0	4.9	2.8	1770.9	0.1
2	23	9	12	638	638	641	348	257	20.5	0.0	5.5	2.3	1758.2	0.1
2	23	9	13	637	637	642	349	257	20.5	0.0	5.2	2.5	1779.8	0.1
2	23	9	14	640	640	647	349	257	20.5	0.0	6.1	2.5	1793.7	0.1
2	23	9	15	643	643	649	347	257	20.5	0.0	6.0	2.3	1844.2	0.1
2	23	9	16	645	646	651	346	257	20.5	0.0	6.1	2.8	1883.5	0.1
2	23	9	17	647	648	654	347	256	20.5	0.0	6.2	2.1	1911.2	0.1
2	23	9	18	648	649	653	351	257	20.5	0.0	5.7	2.6	1904.1	0.1
2	23	9	19	649	650	653	352	258	20.5	0.0	5.6	2.3	1831.5	0.1
2	23	9	20	649	649	653	353	258	20.5	0.0	5.9	2.2	1801.7	0.1
2	23	9	21	647	648	652	352	258	20.5	0.0	5.5	2.7	1796.1	0.1
2	23	9	22	646	647	654	352	258	20.5	0.0	5.7	2.3	1807.2	0.1
2	23	9	23	647	648	654	351	258	20.5	0.0	5.7	2.5	1835.9	0.1
2	23	9	24	648	647	655	351	258	20.5	0.0	6.0	2.6	1864.1	0.1
2	23	9	25	646	646	653	351	258	20.5	0.0	5.4	2.8	1878.7	0.1
2	23	9	26	649	649	654	356	259	20.5	0.0	5.5	2.4	1874.3	0.1
2	23	9	27	648	648	652	359	259	20.5	0.0	5.1	2.5	1798.1	0.1
2	23	9	28	646	646	652	358	260	20.5	0.0	4.7	2.5	1743.1	0.1
2	23	9	29	646	646	651	359	261	20.5	0.0	4.8	2.6	1742.3	0.1
2	23	9	30	646	647	651	358	261	20.5	0.0	5.1	2.2	1755.2	0.1
	Average Base Cas			645	646	636	342	250	20	0	6	2	1746	0
2	23	9	31	648	648	654	358	261	20.2	0.3	176.2	2.2	1811.2	0.1
2	23	9	32	649	650	654	355	261	19.9	0.7	278.1	2.3	1747.2	0.1
2	23	9	33	651	652	655	355	261	19.9	0.8	281.3	2.2	1700.3	0.1
2	23	9	34	652	653	653	359	261	19.9	0.8	271.6	2.3	1666.9	0.1
2	23	9	35	655	654	653	362	262	20.0	0.7	247.0	2.2	1623.0	0.1
2	23	9	36	654	654	653	361	262	20.0	0.7	249.3	2.1	1611.8	0.1
2	23	9	37	654	655	651	359	262	20.0	0.7	227.9	2.1	1568.7	0.1
2	23	9	38	659	659	649	355	262	20.3	0.5	123.8	1.8	1288.6	0.1
2	23	9	39	662	662	648	353	261	20.4	0.2	41.5	1.3	881.2	0.1
2	23	9	40	662	663	646	351	260	20.3	0.3	111.8	0.9	971.7	0.1
2	23	9	41	664	665	644	350	260	20.5	0.1	16.8	1.3	671.5	0.1
2	23	9	42	666	667	642	353	259	20.5	0.1	8.1	0.7	550.0	0.1
2	23	9	43	667	666	641	353	259	20.5	0.0	4.5	0.6	486.6	0.1
2	23	9	44	665	665	641	354	260	20.5	0.0	4.5	0.7	434.9	0.1
2	23	9	45	659	660	642	354	260	20.1	0.6	235.1	1.4	999.7	0.1
2	23	9	46	654	655	641	352	260	19.9	0.8	297.0	1.7	1225.1	0.1
2	23	9	47	651	652	642	351	260	20.0	0.8	261.4	1.8	1299.5	0.1
2	23	9	48	651	650	643	350	259	19.9	0.8	262.2	1.7	1372.7	0.1
2	23	9	49	649	650	642	352	259	19.9	0.8	251.6	1.7	1394.8	0.1
2	23	9	50	649	650	641	357	260	20.1	0.7	197.9	1.9	1349.5	0.1
2	23	9	51	650	650	641	356	261	20.1	0.7	201.1	2.1	1330.3	0.1
2	23	9	52	648	648	640	355	261	20.0	0.7	239.3	1.7	1414.8	0.1
2	23	9	53	646	647	641	354	261	20.0	0.8	229.5	1.9	1420.6	0.1
2	23	9	54	645	646	641	353	261	20.0	0.8	235.0	1.8	1459.0	0.1
2	23	9	55	644	646	642	350	261	19.9	0.8	247.6	1.8	1496.3	0.1
2	23	9	56	644	645	642	350	260	19.9	0.8	246.9	1.8	1512.3	0.1
2	23	9	57	645	646	642	356	261	19.9	0.9	251.2	1.9	1549.3	0.1
2	23	9	58	645	647	641	359	262	20.0	0.7	230.3	2.1	1522.5	0.1
2	23	9	59	644	645	641	360	263	20.0	0.7	278.3	2.3	1595.4	0.1
2	23	10	0	642	644	640	360	263	20.0	0.7	238.4	2.1	1561.6	0.1
2	23	10	1	643	644	642	357	263	19.9	0.8	285.2	2.1	1613.3	0.1
2	23	10	2	642	643	642	354	263	19.9	0.8	237.4	2.0	1596.7	0.1
2	23	10	3	643	643	644	353	262	19.9	0.8	264.2	1.9	1621.1	0.1
2	23	10	4	644	644	643	355	262	19.9	0.9	273.0	2.3	1643.8	0.1
2	23	10	5	646	646	642	360	262	19.9	0.8	273.5	2.1	1661.7	0.1
2	23	10	6	644	645	640	360	263	20.0	0.7	252.8	2.2	1623.3	0.1
2	23	10	7	642	645	639	360	264	20.0	0.8	286.8	2.3	1666.7	0.1
2	23	10	8	642	644	640	359	264	19.9	0.8	291.8	2.3	1694.8	0.1
2	23	10	9	643	644	640	358	264	19.8	0.8	339.5	2.4	1726.4	0.1
2	23	10	10	643	643	639	357	264	19.8	1.0	375.1	2.3	1806.9	0.1
2	23	10	11	642	643	640	354	263	19.9	0.8	290.7	2.5	1766.7	0.1
2	23	10	12	643	643	640	356	263	19.8	0.9	309.3	2.3	1780.5	0.1
2	23	10	13	644	645	638	360	264	19.9	0.8	308.1	2.0	1772.9	0.1
2	23	10	14	644	645	638	357	264	19.7	1.1	532.8	2.3	1846.5	0.1
2	23	10	15	646	647	639	356	264	19.7	1.0	476.1	2.4	1688.3	0.1
2	23	10	16	645	645	640	354	264	19.7	1.0	412.1	2.0	1629.0	0.1
2	23	10	17	647	648	641	353	263	19.7	1.0	360.8	1.9	1619.4	0.1
2	23	10	18	651	652	640	350	263	18.4	1.7	1599.0	2.6	2210.7	0.1

2	23	10	19	655	656	640	348	262	20.0	0.9	474.2	1.6	1479.9	0.1
2	23	10	20	659	660	639	344	261	20.2	0.4	227.4	1.4	1033.2	0.1
2	23	10	21	663	663	637	349	260	20.3	0.3	139.4	1.0	844.1	0.1
2	23	10	22	664	665	636	350	260	20.4	0.2	89.2	1.0	688.3	0.1
2	23	10	23	666	667	636	350	260	20.4	0.1	54.7	1.0	623.9	0.1
2	23	10	24	666	667	635	350	260	20.5	0.1	33.0	0.8	533.6	0.1
2	23	10	25	665	666	634	348	260	20.5	0.1	22.2	0.8	473.6	0.1
2	23	10	26	662	663	636	348	260	20.4	0.1	54.1	1.2	616.8	0.1
2	23	10	27	658	659	636	347	260	19.9	0.8	247.5	1.5	1155.0	0.1
2	23	10	28	653	655	636	346	259	19.8	0.9	280.8	1.5	1340.3	0.1
2	23	10	29	653	654	636	351	259	19.8	1.0	274.0	1.6	1430.2	0.1
2	23	10	30	653	655	635	354	260	20.1	0.7	183.8	1.7	1340.3	0.1
2	23	10	31	651	651	634	355	261	20.2	0.5	151.3	1.6	1259.8	0.1
2	23	10	32	649	650	633	351	261	20.1	0.6	246.3	1.7	1424.2	0.1
2	23	10	33	649	650	633	348	261	19.9	0.8	278.0	1.7	1440.0	0.1
2	23	10	34	647	648	633	347	260	19.8	1.1	358.2	1.9	1554.1	0.1
2	23	10	35	647	648	633	346	260	19.8	1.0	293.5	1.9	1548.8	0.1
2	23	10	36	647	648	634	347	259	19.8	1.0	285.2	1.7	1608.0	0.1
2	23	10	37	647	647	633	350	259	19.8	1.0	287.8	2.0	1611.8	0.1
2	23	10	38	647	648	631	354	260	19.7	1.0	328.0	1.8	1675.4	0.1
2	23	10	39	646	647	631	353	261	19.9	0.9	298.1	2.1	1674.5	0.1
2	23	10	40	644	645	631	353	261	19.9	0.8	291.5	2.0	1704.3	0.1
2	23	10	41	643	643	630	351	261	19.9	0.9	300.2	2.0	1720.4	0.1
2	23	10	42	644	645	632	349	261	19.8	0.9	313.0	2.4	1765.5	0.1
2	23	10	43	644	642	631	348	261	19.8	0.9	327.5	2.1	1816.1	0.1
2	23	10	44	643	644	632	346	260	19.8	0.9	310.8	2.0	1807.8	0.1
2	23	10	45	646	646	632	351	260	19.8	1.0	333.3	2.1	1833.3	0.1
2	23	10	46	646	647	629	354	261	19.9	0.9	303.5	2.3	1822.2	0.1
2	23	10	47	644	645	628	354	261	19.9	0.8	289.5	1.9	1806.1	0.1
2	23	10	48	646	647	628	353	261	19.9	0.8	308.9	2.4	1815.1	0.1
2	23	10	49	645	645	628	350	261	19.7	1.1	487.5	2.6	1939.5	0.1
2	23	10	50	643	643	628	351	261	19.8	0.9	314.1	2.5	1881.5	0.1
2	23	10	51	643	644	629	348	261	19.8	0.9	312.8	2.2	1873.3	0.1
2	23	10	52	643	644	629	349	261	19.8	1.0	369.6	2.6	1938.3	0.1
2	23	10	53	644	645	627	353	261	19.8	0.9	341.4	2.2	1927.9	0.1
2	23	10	54	644	646	627	355	261	19.9	0.8	282.3	2.6	1866.6	0.1
2	23	10	55	645	646	626	354	262	19.8	0.8	399.9	2.2	1935.7	0.1
2	23	10	56	643	644	624	353	262	19.9	0.8	277.8	2.3	1853.0	0.1
2	23	10	57	643	642	626	352	262	19.8	0.9	356.7	2.4	1910.3	0.1
2	23	10	58	655	656	633	352	262	19.8	0.9	312.2	2.2	1895.0	61.9
2	23	10	59	654	655	635	349	261	18.0	4.1	1820.2	2.8	2520.1	0.1
Average Base Case 2				**650**	**650**	**638**	**353**	**261**	**19.9**	**0.8**	**290**	**2**	**1500**	**1**
2	23	11	0	651	652	635	349	261	20.0	0.8	275.9	2.5	1900.7	0.1
2	23	11	1	655	654	635	356	261	20.0	0.7	270.5	2.1	1839.1	0.1
2	23	11	2	665	666	639	352	261	20.0	0.7	290.6	2.5	1802.6	0.1
2	23	11	3	671	671	644	351	261	19.7	1.0	410.9	2.5	1777.8	0.1
2	23	11	4	674	676	647	348	260	19.8	0.8	325.7	1.9	1702.8	0.1
2	23	11	5	678	679	649	348	260	19.5	1.2	399.4	2.3	1756.9	0.1
2	23	11	6	682	682	653	347	260	19.6	1.2	344.6	2.2	1796.1	0.1
2	23	11	7	683	683	655	346	259	19.6	1.2	408.8	2.2	1809.8	0.1
2	23	11	8	684	685	656	343	259	19.2	1.5	788.9	2.2	2071.8	0.1
2	23	11	9	686	687	656	344	258	19.6	1.1	320.2	2.3	1786.6	0.1
2	23	11	10	688	689	657	349	258	19.6	1.1	405.4	2.3	1847.1	0.1
2	23	11	11	684	689	657	349	258	19.7	1.1	346.5	2.0	1737.6	0.1
2	23	11	12	685	689	657	349	258	19.8	0.9	329.3	2.2	1691.6	0.1
2	23	11	13	687	689	658	348	258	19.9	0.7	290.3	1.9	1548.4	0.1
2	23	11	14	687	688	658	346	258	19.9	0.9	245.8	2.0	1514.3	1.1
2	23	11	15	687	689	658	345	258	19.5	1.5	744.9	2.3	1875.7	0.1
2	23	11	16	690	690	658	342	257	19.5	1.2	421.1	2.1	1774.9	0.1
2	23	11	17	691	692	658	346	257	19.6	1.1	329.4	2.2	1801.9	0.1
2	23	11	18	691	691	656	349	257	19.8	0.9	251.2	2.5	1659.4	0.1
2	23	11	19	692	692	655	351	258	19.6	1.1	420.0	1.5	1766.8	0.1
2	23	11	20	690	690	656	353	258	19.8	1.0	336.2	2.3	1762.2	3.0
2	23	11	21	688	688	655	351	258	18.5	3.1	1402.1	2.7	2064.5	0.1
2	23	11	22	688	689	654	351	258	19.2	1.6	899.6	2.0	1655.4	0.1
2	23	11	23	690	691	655	351	258	19.5	1.2	701.0	1.9	1545.5	0.1
2	23	11	24	691	692	655	351	258	19.6	1.1	590.4	2.1	1485.8	0.1
2	23	11	25	692	692	655	350	258	19.6	1.1	503.4	1.8	1396.0	0.1
2	23	11	26	695	695	657	351	258	19.5	1.2	472.5	2.0	1446.7	0.1

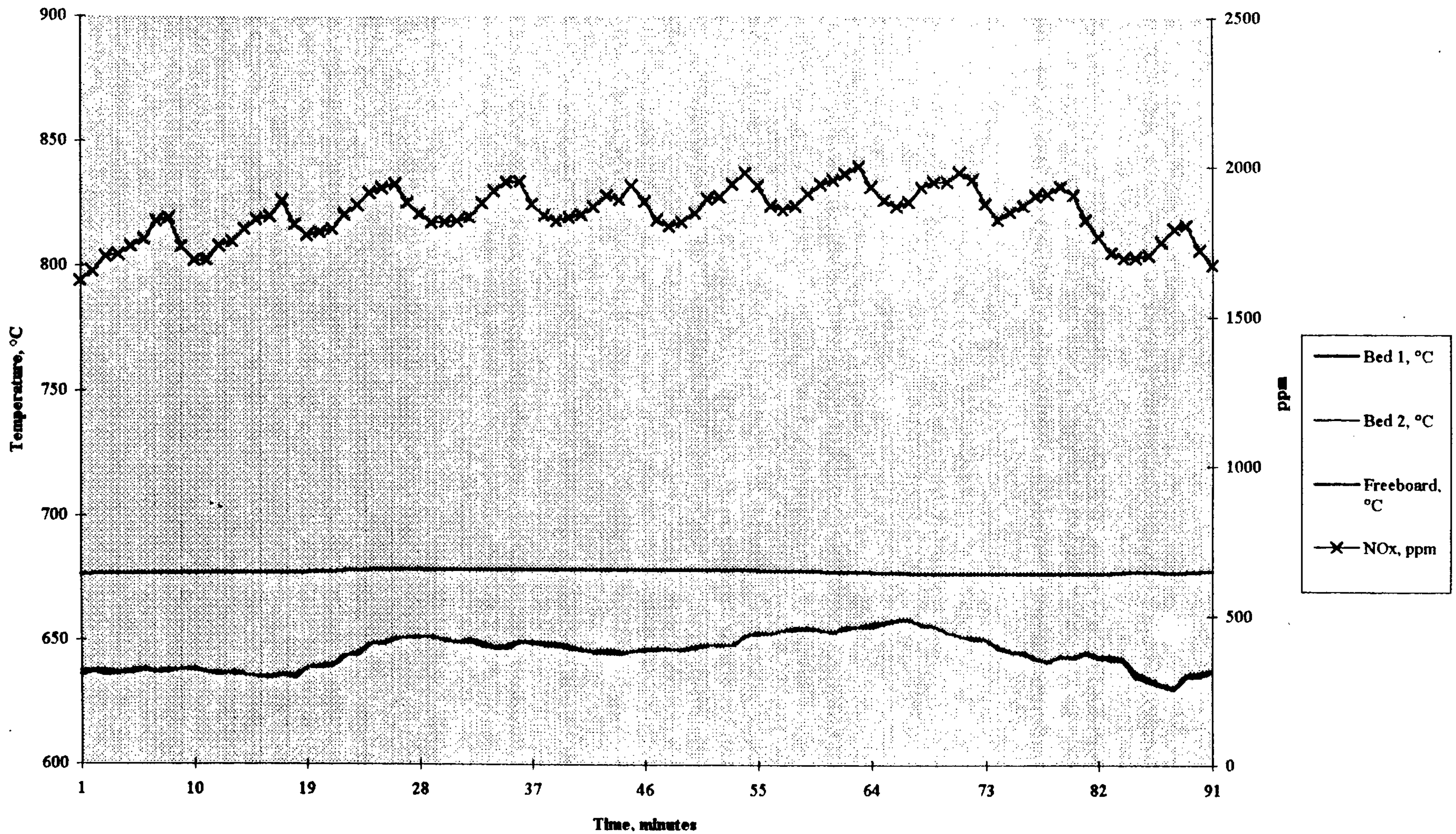
2	23	11	27	696	698	657	350	258	19.5	1.2	410.5	2.0	1435.5	0.1
2	23	11	28	697	697	657	349	257	19.6	1.2	330.5	1.7	1438.9	0.1
2	23	11	29	697	697	658	349	257	19.6	1.1	304.0	2.1	1499.8	0.1
Start Test 1														
2	23	11	30	697	697	658	349	257	19.6	1.2	278.5	1.8	1560.5	0.1
2	23	11	31	698	698	660	350	257	19.5	1.2	294.5	1.9	1597.3	0.1
2	23	11	32	698	699	658	349	257	19.7	1.1	280.2	2.0	1653.1	0.1
2	23	11	33	697	698	658	349	257	19.7	1.1	284.7	2.3	1726.3	0.1
2	23	11	34	698	699	657	358	257	19.7	1.1	290.2	2.4	1800.1	0.1
2	23	11	35	696	698	655	360	258	19.8	0.9	310.3	2.2	1802.5	0.1
2	23	11	36	696	696	653	363	260	19.9	0.8	277.9	1.9	1774.3	0.1
2	23	11	37	693	694	651	362	260	19.8	0.8	277.0	2.2	1790.5	0.1
2	23	11	38	694	694	651	363	261	19.8	0.9	320.7	2.4	1843.6	0.1
2	23	11	39	694	694	652	365	262	19.8	0.9	328.4	2.6	1871.1	0.1
2	23	11	40	692	691	650	364	262	19.8	0.9	278.8	2.3	1827.3	0.1
2	23	11	41	692	693	651	363	262	19.8	0.9	273.5	2.3	1834.5	0.1
2	23	11	42	693	694	653	362	262	19.8	1.0	329.6	2.3	1891.1	0.1
2	23	11	43	693	693	652	361	262	19.8	0.9	301.9	2.1	1900.9	0.1
2	23	11	44	693	693	653	360	262	19.8	0.9	297.5	2.4	1905.2	0.1
2	23	11	45	694	694	654	360	262	19.7	1.0	346.8	2.7	1955.0	0.1
2	23	11	46	695	695	654	359	262	19.7	1.0	302.4	2.3	1945.3	0.1
2	23	11	47	694	693	654	361	262	19.6	1.1	352.5	2.3	1993.2	0.1
2	23	11	48	693	694	651	368	263	19.8	0.9	297.0	2.7	1959.8	0.1
2	23	11	49	698	698	652	366	264	19.8	0.9	332.0	2.6	1959.0	0.1
2	23	11	50	696	698	651	365	264	19.3	2.1	945.8	2.8	2164.6	0.1
2	23	11	51	694	695	650	363	264	19.6	1.1	497.8	2.3	1878.3	0.1
2	23	11	52	693	694	650	363	264	19.6	1.1	403.5	2.4	1777.4	0.1
2	23	11	53	694	696	650	361	264	19.6	1.1	368.6	2.2	1752.1	0.1
2	23	11	54	694	695	650	360	263	19.6	1.1	331.0	2.1	1755.9	0.1
2	23	11	55	693	694	651	358	263	19.6	1.1	281.9	2.6	1772.7	0.1
2	23	11	56	694	695	650	358	263	19.6	1.1	293.6	2.6	1837.7	0.1
2	23	11	57	700	701	656	356	262	19.6	1.1	290.7	2.4	1843.9	0.1
2	23	11	58	700	702	665	355	262	19.6	1.1	282.6	2.5	1885.6	0.1
2	23	11	59	702	702	669	353	261	19.6	1.1	310.7	2.5	1913.9	0.1
2	23	12	0	701	702	669	352	261	19.5	1.2	323.0	2.3	1973.5	0.1
2	23	12	1	702	703	669	354	260	19.6	1.1	296.8	2.4	1974.7	0.1
2	23	12	2	702	702	667	358	260	19.7	1.0	275.2	2.5	1930.7	0.1
2	23	12	3	699	700	665	359	261	19.7	0.9	290.8	2.5	1938.5	0.1
2	23	12	4	700	700	663	358	261	19.8	0.9	295.2	2.4	1932.7	0.1
2	23	12	5	698	699	662	357	261	19.7	0.9	293.3	2.5	1922.6	0.1
2	23	12	6	699	699	663	357	261	19.8	0.9	286.2	2.8	1923.1	0.1
2	23	12	7	698	699	660	356	261	19.6	1.2	410.2	2.6	2021.3	0.1
2	23	12	8	700	701	664	358	261	19.7	1.0	290.2	2.5	1971.2	0.1
2	23	12	9	700	701	663	357	261	19.7	1.0	289.0	2.5	1973.7	0.1
2	23	12	10	700	700	663	357	261	19.7	1.0	344.6	2.4	2009.4	0.1
2	23	12	11	698	698	661	355	261	19.7	1.0	348.2	2.6	2016.3	0.1
2	23	12	12	699	699	661	354	261	19.6	1.0	332.2	2.4	2015.5	0.1
2	23	12	13	698	698	663	352	261	19.7	1.0	313.8	2.4	2037.9	0.1
2	23	12	14	697	698	663	351	260	19.7	1.0	297.3	3.0	2017.2	0.1
2	23	12	15	699	700	662	353	260	19.7	1.1	306.3	2.9	2045.4	0.1
2	23	12	16	698	699	660	360	260	19.8	1.0	298.7	3.0	1989.2	0.1
2	23	12	17	699	700	660	361	261	18.6	1.7	1328.4	3.1	2427.3	0.1
2	23	12	18	696	698	658	361	262	19.7	1.0	368.7	2.7	2008.9	0.1
2	23	12	19	695	698	656	361	262	19.8	1.0	338.9	2.4	1932.6	0.1
2	23	12	20	694	697	657	361	262	19.9	0.8	288.7	2.4	1809.8	0.1
2	23	12	21	689	696	658	359	262	19.8	0.9	327.9	2.0	1762.2	0.1
2	23	12	22	688	696	657	360	262	19.7	1.0	357.0	2.2	1794.0	0.1
2	23	12	23	685	696	657	359	262	19.7	1.0	367.0	2.3	1825.6	0.1
2	23	12	24	677	696	657	358	262	19.7	1.1	357.5	2.6	1851.7	0.1
2	23	12	25	684	696	658	357	262	19.7	1.0	363.9	2.2	1857.4	0.1
2	23	12	26	694	696	657	355	262	19.6	1.2	519.8	2.6	1965.0	0.1
2	23	12	27	695	696	657	355	261	19.7	1.0	310.2	2.2	1840.2	0.1
2	23	12	28	697	696	657	354	261	19.7	1.0	313.6	2.0	1844.4	0.1
2	23	12	29	695	696	658	359	261	19.8	1.0	277.3	2.2	1866.1	0.1
2	23	12	30	691	692	666	370	263	19.9	0.8	299.7	2.4	1891.9	42.9
Average Test 1				696	697	658	358	261	19.7	1.0	347	2	1894	1
2	23	12	31	684	685	671	370	264	18.6	2.6	1557.6	2.7	2247.5	0.1
2	23	12	32	686	687	671	369	264	19.5	1.3	850.2	2.3	1793.7	0.1
2	23	12	33	689	690	673	364	264	19.8	0.9	585.0	2.3	1599.8	0.1

2	23	12	34	694	695	676	365	264	19.8	0.9	538.7	1.9	1591.6	0.1
2	23	12	35	706	706	683	366	264	19.6	1.0	531.3	2.0	1559.3	0.1
2	23	12	36	711	712	687	364	264	19.6	1.1	396.7	2.2	1521.9	0.1
2	23	12	37	715	715	689	363	264	19.5	1.2	406.3	1.9	1599.1	0.1
2	23	12	38	717	718	691	365	263	19.5	1.1	331.1	2.0	1606.4	0.1
2	23	12	39	721	722	691	362	263	19.6	1.2	280.5	2.0	1615.5	12.4
2	23	12	40	725	727	689	359	263	19.2	2.0	877.7	2.2	1850.1	0.1
2	23	12	41	731	732	689	357	262	20.1	0.6	140.3	1.6	1169.9	0.1
2	23	12	42	736	738	690	356	261	20.3	0.3	57.9	1.1	975.7	0.1
2	23	12	43	739	740	689	358	260	20.4	0.2	32.3	1.1	829.6	0.1
2	23	12	44	740	741	689	364	261	20.4	0.2	26.8	1.3	800.9	0.1
2	23	12	45	738	739	689	367	262	20.3	0.2	59.0	1.1	928.2	0.1
2	23	12	46	734	735	688	365	262	20.1	0.4	95.3	1.8	1191.9	0.1
2	23	12	47	734	734	688	365	262	19.9	0.8	168.1	1.5	1430.4	0.1
2	23	12	48	732	733	686	364	262	19.8	0.9	183.1	1.6	1525.4	0.1
2	23	12	49	734	736	687	364	262	19.8	0.9	181.8	2.2	1584.2	0.1
2	23	12	50	738	737	686	362	262	20.0	0.9	273.7	1.9	1642.6	0.1
2	23	12	51	741	742	686	360	261	20.3	0.4	116.5	1.4	1205.0	0.1
2	23	12	52	744	745	686	358	261	20.3	0.3	58.6	1.1	854.0	0.1
Start Test 2														
2	23	12	53	749	749	689	358	260	20.4	0.2	42.3	1.0	734.0	0.1
2	23	12	54	751	751	691	354	259	20.4	0.1	37.1	1.0	682.4	0.1
2	23	12	55	753	754	690	352	259	20.5	0.1	18.3	0.8	585.1	0.1
2	23	12	56	755	755	690	352	258	20.5	0.0	13.9	0.4	502.2	0.1
2	23	12	57	752	753	691	356	258	20.2	0.3	67.6	1.1	883.3	0.1
2	23	12	58	751	751	691	364	258	20.1	0.7	114.0	1.6	1133.1	0.1
2	23	12	59	748	748	689	364	259	20.0	0.7	147.8	1.8	1244.3	0.1
2	23	13	0	744	744	687	365	260	19.8	0.9	197.2	1.7	1446.7	0.1
2	23	13	1	743	743	687	365	261	19.8	0.8	201.1	2.2	1545.7	0.1
2	23	13	2	744	746	685	360	260	19.9	0.9	273.3	2.0	1724.9	0.1
2	23	13	3	746	747	684	353	260	20.3	0.4	70.1	1.7	1059.8	0.1
2	23	13	4	748	748	682	344	259	20.4	0.1	26.9	1.4	811.6	0.1
2	23	13	5	746	746	684	336	259	20.3	0.2	47.4	1.3	907.9	0.1
2	23	13	6	744	744	684	329	259	20.0	0.5	131.9	1.3	1318.4	0.1
2	23	13	7	744	744	684	322	259	19.7	0.9	206.3	2.3	1587.0	0.1
2	23	13	8	741	743	683	315	260	19.8	0.9	222.1	2.0	1726.0	0.1
2	23	13	9	741	742	684	310	260	19.8	0.9	206.7	2.0	1761.2	0.1
2	23	13	10	740	741	683	357	259	19.7	0.9	222.9	2.4	1839.6	0.1
2	23	13	11	739	741	683	363	260	19.7	0.9	221.6	2.5	1892.6	0.1
2	23	13	12	739	739	681	370	261	19.9	0.8	229.5	2.5	1866.9	0.1
2	23	13	13	739	739	681	372	262	19.9	0.8	222.8	2.2	1863.7	0.1
2	23	13	14	741	741	679	372	263	19.8	0.9	303.4	2.1	1941.5	0.1
2	23	13	15	743	743	681	373	264	19.9	0.8	207.6	2.2	1866.3	0.1
2	23	13	16	744	744	681	374	264	20.0	0.8	192.0	2.7	1922.3	0.1
2	23	13	17	745	746	681	374	265	19.8	0.9	251.9	1.9	1984.1	0.1
2	23	13	18	745	746	682	375	265	19.8	0.9	225.0	2.3	1967.6	0.1
2	23	13	19	745	746	682	373	265	18.8	1.6	1211.0	2.7	2151.9	0.1
2	23	13	20	746	747	682	372	265	19.6	1.2	343.3	2.3	1919.2	0.1
2	23	13	21	747	747	682	371	265	19.8	0.9	198.8	2.5	1825.5	0.1
2	23	13	22	748	749	681	370	265	19.8	0.8	169.9	2.6	1817.0	0.1
2	23	13	23	757	758	708	373	265	19.8	0.9	151.3	2.4	1818.8	0.1
2	23	13	24	757	756	713	371	265	19.7	0.9	140.0	2.4	1861.2	0.1
2	23	13	25	753	754	712	379	266	19.7	1.0	139.9	2.3	1891.4	0.1
2	23	13	26	749	751	709	387	267	19.8	0.9	181.2	2.5	1875.8	0.1
2	23	13	27	746	747	706	381	268	19.8	0.9	205.7	2.3	1871.9	0.1
2	23	13	28	744	744	706	380	268	19.8	0.9	194.2	2.0	1902.7	0.1
2	23	13	29	741	742	706	378	268	19.7	1.0	219.0	2.3	1938.9	0.1
2	23	13	30	740	741	705	377	268	19.7	1.0	225.6	2.6	1945.5	0.1
2	23	13	31	741	742	704	375	268	19.7	0.9	216.6	2.2	1968.2	0.1
2	23	13	32	741	741	703	374	268	19.7	1.0	223.2	2.4	1977.6	0.1
2	23	13	33	741	741	704	372	267	19.7	1.0	211.7	2.4	1988.7	0.1
2	23	13	34	744	744	704	371	267	19.7	1.0	214.3	2.4	1995.1	0.1
2	23	13	35	745	745	704	369	267	19.8	0.9	191.0	2.1	1956.0	0.1
2	23	13	36	746	745	704	366	266	19.7	1.0	189.9	2.8	1967.8	0.1
2	23	13	37	745	746	703	364	266	20.0	0.7	116.6	2.0	1804.0	0.1
2	23	13	38	746	747	704	363	265	19.8	0.8	171.4	2.5	1856.2	0.1
2	23	13	39	748	746	703	363	265	19.9	0.9	144.1	2.2	1822.9	0.1
2	23	13	40	749	748	701	370	265	19.8	0.8	172.1	2.1	1781.6	0.1
2	23	13	41	746	747	701	369	265	19.9	0.9	218.6	2.4	1799.1	0.1

2	23	13	42	743	744	700	370	265	20.2	0.5	156.2	2.0	1648.3	0.1
2	23	13	43	743	743	699	370	266	20.3	0.3	81.0	2.1	1407.2	0.1
2	23	13	44	741	741	699	369	266	20.1	0.4	166.1	1.9	1518.6	0.1
2	23	13	45	741	742	699	369	266	20.0	0.7	251.2	2.3	1748.4	0.1
2	23	13	46	745	743	701	369	266	20.2	0.5	101.9	1.9	1500.9	0.1
2	23	13	47	745	747	703	367	265	20.1	0.5	100.2	1.7	1476.6	0.1
Average Test 2				**745**	**746**	**693**	**364**	**263**	**19.9**	**0.7**	**189**	**2**	**1633**	**0**
2	23	13	48	729	749	704	366	265	19.8	0.9	212.4	2.1	1675.5	0.1
2	23	13	49	717	755	705	365	265	20.0	0.6	120.6	1.9	1556.3	0.1
2	23	13	50	733	757	706	364	265	19.8	0.9	205.3	2.0	1647.6	0.1
2	23	13	51	717	760	707	362	264	20.2	0.5	84.2	2.0	1441.9	0.1
2	23	13	52	712	761	706	360	264	20.1	0.6	116.5	1.9	1394.8	0.1
2	23	13	53	719	764	706	360	263	20.4	0.3	39.8	1.5	1115.3	0.1
2	23	13	54	721	778	717	354	263	20.4	0.2	26.4	1.5	967.4	0.1
2	23	13	55	729	772	718	350	264	20.4	0.2	33.5	1.0	953.7	0.1
2	23	13	56	709	760	716	377	264	20.5	0.1	15.8	1.2	793.2	0.1
2	23	13	57	698	755	713	376	265	20.4	0.1	43.9	1.3	953.4	0.1
2	23	13	58	736	756	714	376	265	20.5	0.1	23.4	0.9	772.6	1.9
2	23	13	59	756	762	714	372	265	18.3	3.8	1235.0	2.5	2097.6	0.1
2	23	14	0	757	763	710	368	265	18.5	3.4	467.2	2.3	1808.3	0.1
2	23	14	1	767	764	709	366	264	19.1	1.7	81.8	1.7	1183.2	0.1
2	23	14	2	768	765	708	365	263	19.2	1.3	56.8	1.2	979.4	0.1
2	23	14	3	767	768	708	365	263	19.3	1.2	126.9	1.5	889.2	0.1
2	23	14	4	768	781	714	364	263	19.8	0.8	49.6	1.0	793.2	0.1
2	23	14	5	775	798	722	363	262	20.1	0.4	26.4	1.1	707.8	0.1
2	23	14	6	784	811	732	361	261	20.3	0.2	14.2	0.7	639.9	0.1
2	23	14	7	777	815	738	361	261	20.4	0.1	8.9	0.9	574.7	0.1
2	23	14	8	769	815	741	367	261	20.4	0.2	8.2	0.6	512.2	0.1
2	23	14	9	767	810	738	373	261	20.4	0.1	13.0	1.0	545.1	0.1
2	23	14	10	769	807	738	378	261	20.5	0.0	6.9	0.8	445.0	0.1
2	23	14	11	750	801	739	383	262	20.5	0.1	5.7	0.9	476.3	0.1
2	23	14	12	745	796	739	383	263	20.4	0.1	9.8	0.8	587.8	0.1
2	23	14	13	766	793	737	381	264	20.4	0.2	18.4	0.9	723.7	0.1
2	23	14	14	765	782	730	376	264	20.2	0.4	38.3	1.0	728.3	0.1
2	23	14	15	755	767	719	376	263	20.0	0.8	160.8	1.5	1042.4	0.1
2	23	14	16	744	754	710	371	263	20.2	0.4	34.2	0.7	582.8	0.1
2	23	14	17	738	747	703	372	263	20.4	0.2	26.0	0.7	499.6	0.1
2	23	14	18	735	744	698	369	262	20.5	0.0	16.2	0.8	446.1	0.1
2	23	14	19	733	741	695	367	262	20.5	0.0	9.4	0.5	406.2	0.1
2	23	14	20	727	735	693	365	261	20.5	0.0	7.1	0.5	372.7	0.1
2	23	14	21	713	725	695	363	261	20.6	0.0	8.6	0.7	354.2	0.1
2	23	14	22	708	720	695	365	260	20.6	0.0	6.1	0.4	341.7	0.1
2	23	14	23	710	714	696	372	260	20.6	0.0	6.2	0.2	323.4	0.1
2	23	14	24	707	710	695	371	261	20.6	0.0	6.5	0.0	333.7	0.1
2	23	14	25	707	709	697	371	261	20.6	0.0	7.8	0.4	338.6	0.1
2	23	14	26	710	712	698	370	261	20.6	0.0	5.8	0.2	319.5	0.1
2	23	14	27	713	715	699	370	261	20.6	0.0	5.1	0.2	298.1	0.1
2	23	14	28	717	720	699	370	261	20.6	0.0	4.5	0.6	276.3	0.1
2	23	14	29	722	722	700	369	261	20.6	0.0	3.8	0.0	263.6	0.1
2	23	14	30	729	730	703	369	261	20.6	0.0	2.8	0.2	251.3	0.1
2	23	14	31	747	748	713	367	261	20.6	0.0	1.4	0.3	240.5	0.1
2	23	14	32	767	769	727	369	260	20.6	0.0	-0.4	0.1	234.9	0.1
2	23	14	33	785	787	739	367	260	20.6	0.0	-1.4	0.5	234.2	0.1
2	23	14	34	797	799	747	367	260	20.6	0.0	-2.6	0.3	233.4	0.1
2	23	14	35	804	806	753	366	259	20.6	0.0	-2.4	0.5	232.9	0.1
2	23	14	36	812	812	757	368	259	20.6	0.0	-2.7	0.2	226.3	0.1
2	23	14	37	816	818	761	380	259	20.6	0.0	-2.7	0.2	217.4	0.1
2	23	14	38	815	816	762	381	260	20.6	0.0	-2.5	0.0	204.3	0.1
2	23	14	39	815	817	763	383	261	20.6	0.0	-2.4	0.2	196.2	0.1
2	23	14	40	807	808	764	387	261	20.5	0.0	-1.2	0.3	252.9	0.1
2	23	14	41	800	802	766	389	263	20.1	0.5	12.1	1.6	1052.5	0.1
Start Test 3														
2	23	14	42	801	803	768	389	264	19.9	0.9	22.3	1.3	1402.7	0.1
2	23	14	43	793	796	769	390	264	20.3	0.4	5.9	1.4	1043.3	0.1
2	23	14	44	784	786	767	392	265	20.1	0.6	20.2	1.5	1355.1	0.1
2	23	14	45	780	781	766	392	265	19.8	0.9	33.2	1.9	1548.5	0.1
2	23	14	46	781	784	768	391	266	19.8	1.0	36.0	2.1	1626.9	0.1
2	23	14	47	786	788	771	392	267	19.8	0.9	24.0	2.0	1672.7	0.1
2	23	14	48	789	791	772	391	267	19.6	1.1	28.3	2.2	1880.9	0.1

2	23	14	49	793	794	773	392	267	19.6	1.1	28.9	2.3	1953.5	0.1
2	23	14	50	796	796	774	394	267	19.9	0.8	15.4	2.2	1818.8	0.1
2	23	14	51	800	801	773	402	268	19.8	1.0	29.8	2.0	1904.5	0.1
2	23	14	52	801	803	772	405	270	19.8	1.0	41.0	2.6	1932.0	0.1
2	23	14	53	802	803	770	405	271	20.1	0.6	25.9	1.9	1677.5	0.1
2	23	14	54	803	805	768	407	272	20.4	0.3	9.1	1.8	1228.4	0.1
2	23	14	55	801	804	767	408	273	20.3	0.4	14.2	1.9	1311.6	0.1
2	23	14	56	801	804	767	409	274	20.2	0.4	14.5	2.3	1346.1	0.1
2	23	14	57	800	803	766	407	274	20.1	0.6	37.4	1.7	1622.2	0.1
2	23	14	58	801	804	768	408	275	20.0	0.5	24.3	1.9	1580.6	0.1
2	23	14	59	806	810	768	407	275	19.7	1.0	35.4	2.0	1860.1	0.1
2	23	15	0	804	809	769	405	275	19.9	0.8	20.6	2.4	1758.0	0.1
2	23	15	1	803	809	769	405	275	19.8	0.9	24.0	2.3	1838.1	0.1
2	23	15	2	801	809	769	403	275	19.6	1.1	36.2	2.7	1985.5	0.1
2	23	15	3	797	807	768	403	275	19.6	1.2	33.7	2.4	2010.8	0.1
2	23	15	4	796	807	768	405	276	19.7	1.1	29.8	2.7	1975.7	0.1
2	23	15	5	792	806	768	414	277	19.8	1.0	41.6	2.5	1913.0	0.1
2	23	15	6	797	806	769	417	278	20.0	1.0	59.9	2.5	1767.0	0.1
2	23	15	7	803	812	772	418	280	20.0	0.7	27.5	1.8	1554.9	0.1
2	23	15	8	809	819	780	420	281	20.3	0.4	11.0	1.4	1252.9	0.1
2	23	15	9	809	825	787	420	281	20.2	0.4	15.1	1.6	1346.8	0.1
2	23	15	10	805	824	792	420	282	20.1	0.7	20.5	2.1	1603.3	0.1
2	23	15	11	798	826	795	421	282	20.3	0.4	4.7	1.8	1263.5	0.1
2	23	15	12	802	834	798	421	282	20.2	0.4	8.3	1.7	1366.4	0.1
Average Test 3				**798**	**805**	**773**	**405**	**273**	**20.0**	**0.8**	**25**	**2**	**1626**	**0**
2	23	15	13	800	844	794	415	282	17.6	3.7	643.5	2.4	1876.6	0.1
2	23	15	14	792	834	784	413	281	19.1	2.4	70.7	2.0	1747.3	0.1
2	23	15	15	787	818	770	409	280	19.4	1.4	37.0	2.1	1523.9	0.1
2	23	15	16	780	800	757	406	279	19.7	0.9	13.1	1.3	1028.5	0.1
2	23	15	17	770	782	742	402	278	20.0	0.6	14.1	1.2	838.6	0.1
2	23	15	18	756	765	730	404	278	20.2	0.4	17.1	1.2	703.7	0.1
2	23	15	19	745	751	719	405	278	20.4	0.2	36.3	0.9	607.0	0.1
2	23	15	20	734	738	711	404	278	20.4	0.1	50.5	0.8	533.2	0.1
2	23	15	21	725	729	704	401	278	20.5	0.1	50.2	0.6	479.1	0.1
2	23	15	22	721	724	700	398	278	20.5	0.1	57.1	0.6	445.5	0.1
2	23	15	23	719	722	696	396	277	20.5	0.1	43.3	0.5	428.3	0.1
2	23	15	24	721	722	695	395	277	20.6	0.0	16.8	0.4	408.9	0.1
2	23	15	25	721	723	694	392	276	20.6	0.0	10.9	0.6	379.9	0.1
2	23	15	26	720	723	692	390	276	20.6	0.0	9.1	0.3	357.3	0.1
2	23	15	27	721	723	691	386	275	20.6	0.0	8.7	0.2	338.2	0.1
2	23	15	28	733	744	696	383	274	20.6	0.0	8.1	0.4	319.8	0.1
2	23	15	29	737	742	683	376	275	20.5	0.0	10.9	0.4	328.3	0.1
2	23	15	30	729	734	674	369	275	20.6	0.0	8.3	0.1	328.2	0.1
2	23	15	31	713	722	663	365	274	20.6	0.0	9.0	0.6	338.4	0.1
2	23	15	32	688	705	653	359	273	20.6	0.0	8.2	0.7	341.8	0.1
2	23	15	33	667	690	644	353	271	20.6	0.0	7.8	0.4	347.9	3.5
2	23	15	34	658	679	635	348	269	20.6	0.0	-0.5	0.2	281.4	0.3
2	23	15	35	646	669	625	343	267	20.6	0.0	-3.4	0.4	236.8	0.1
2	23	15	36	638	659	617	337	265	20.6	0.0	-4.3	0.5	219.9	0.1
2	23	15	37	627	648	608	331	262	20.6	0.0	-4.4	0.1	208.7	0.0
2	23	15	38	618	639	599	324	259	20.6	0.0	-4.2	-0.2	197.2	0.0
2	23	15	39	610	630	591	320	257	20.6	0.0	-4.7	-0.2	186.9	0.0
2	23	15	40	601	621	584	313	254	20.6	0.0	-4.7	0.4	180.6	0.0
2	23	15	41	593	613	576	308	251	20.6	0.0	-5.0	0.3	174.5	0.0
2	23	15	42	586	606	571	303	249	20.6	0.0	-4.9	0.4	170.4	0.0

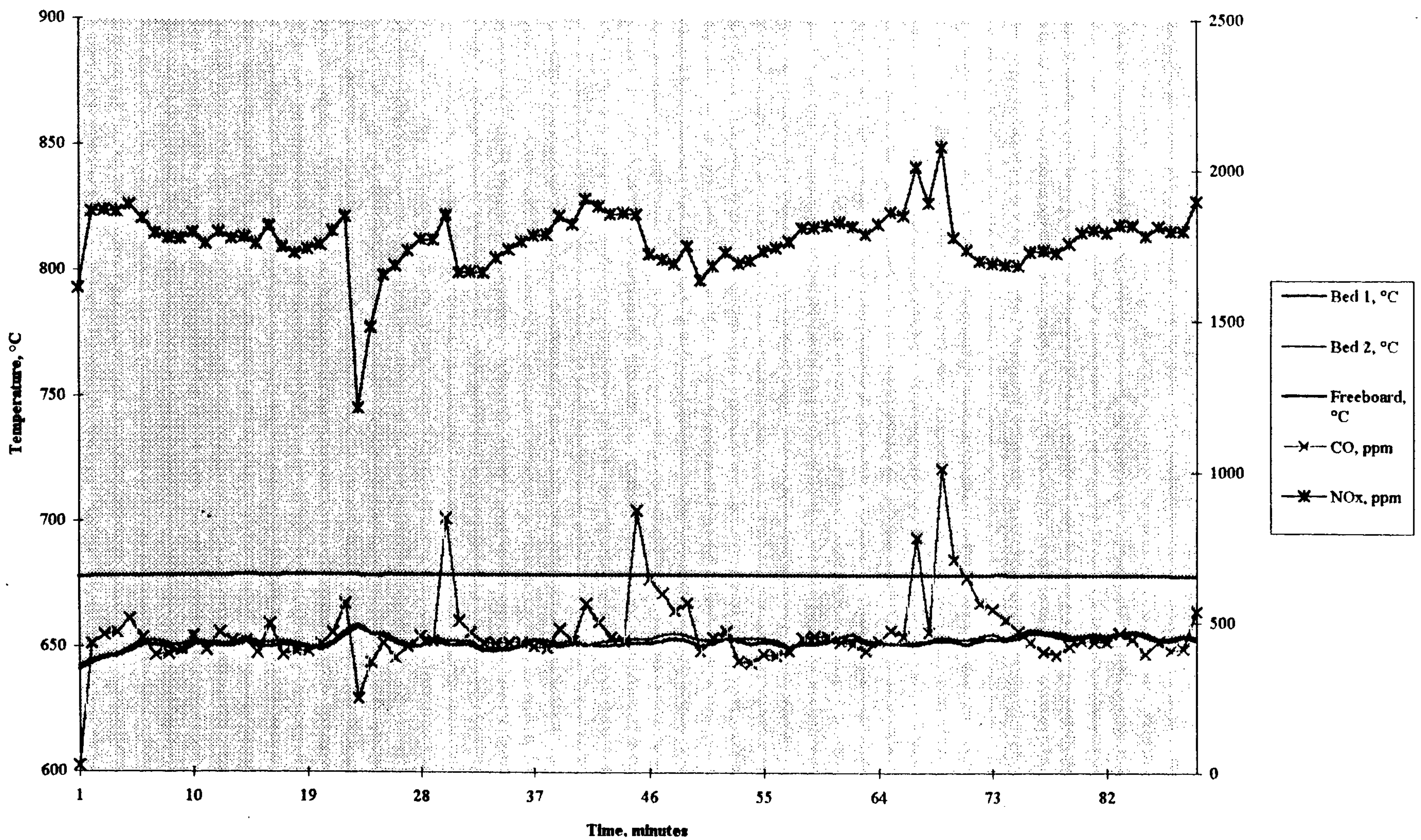
Zircon Sand, Base Case 1



Fluidized Bed Temperature and Offgas Emissions Profile

Hazen Research, Inc.

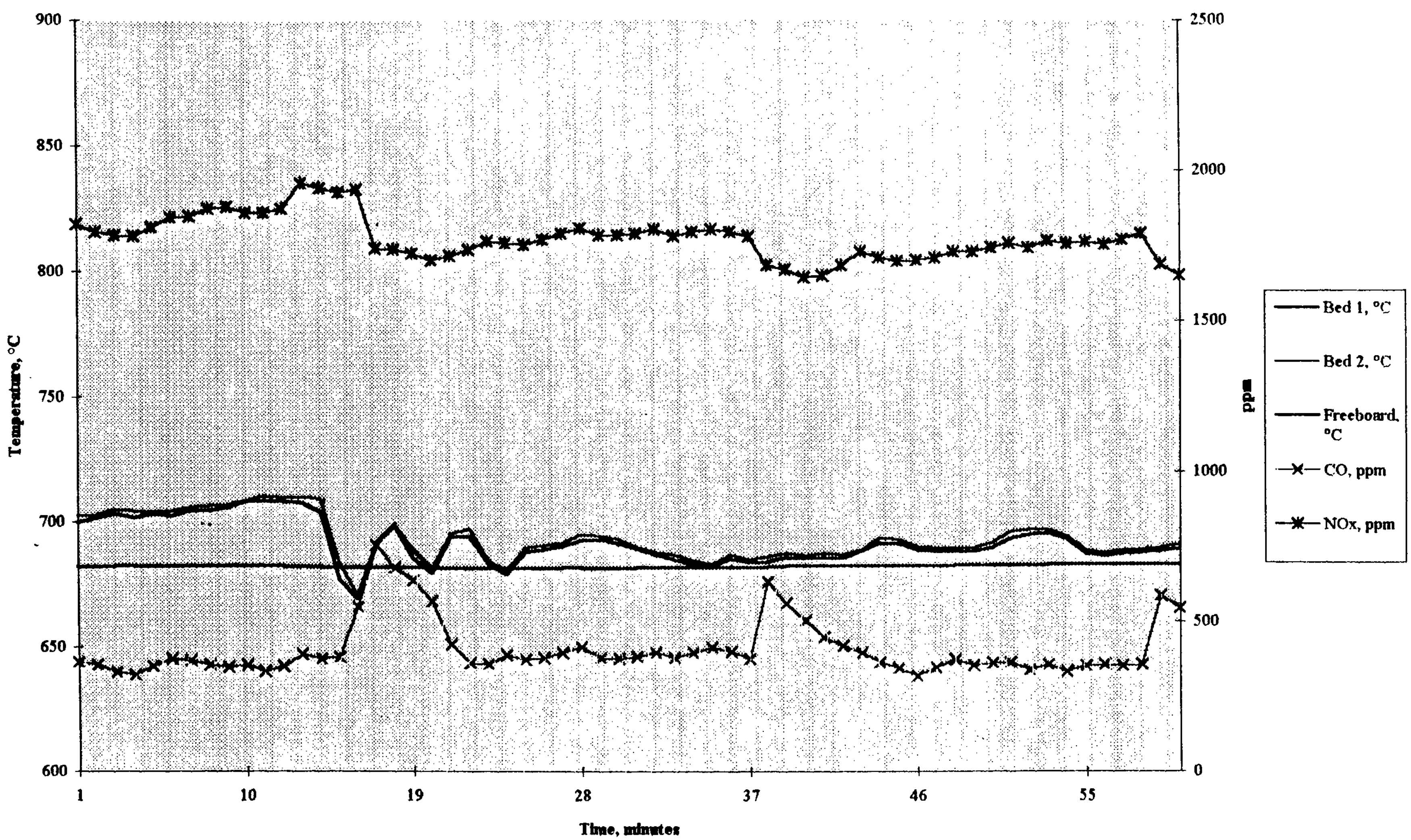
Zircon Sand, Base Case 2



Fluidized Bed Temperature and Offgas Emissions Profile

Hazen Research, Inc.

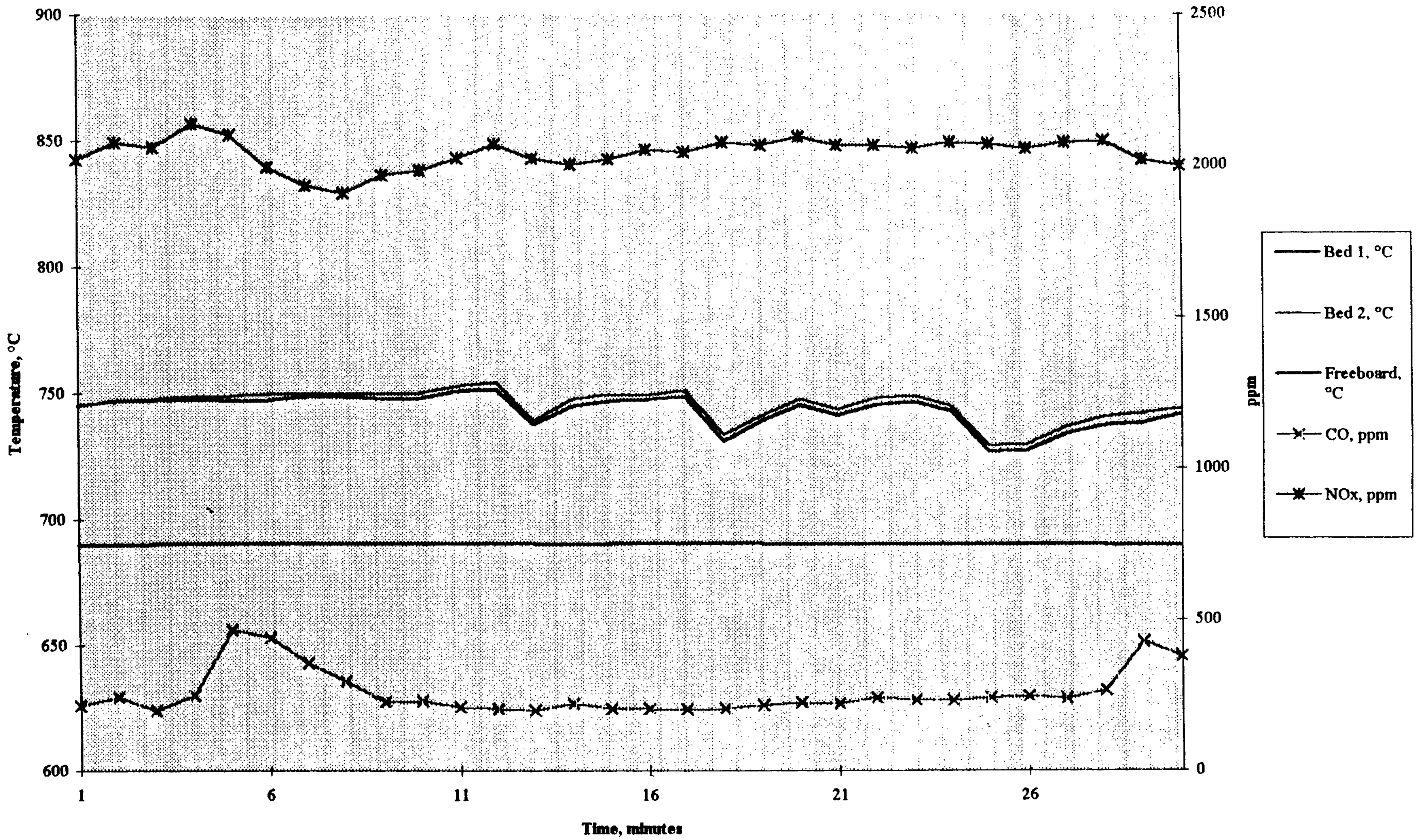
Zircon Sand, Test 1



Fluidized Bed Temperature and Offgas Emissions Profile

Hazen Research, Inc.

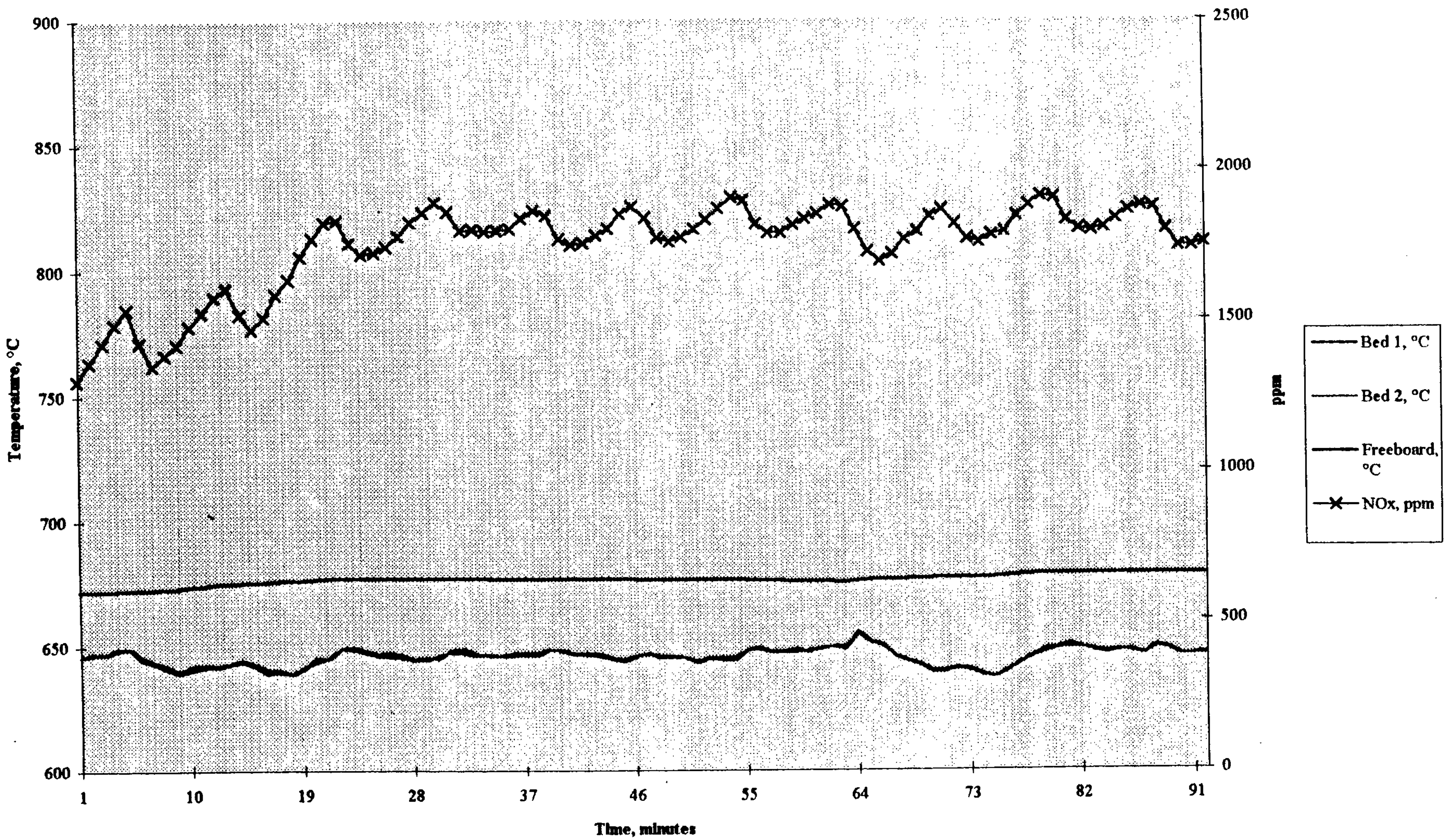
Zircon Sand, Test 2



Fluidized Bed Temperature and Offgas Emissions Profile

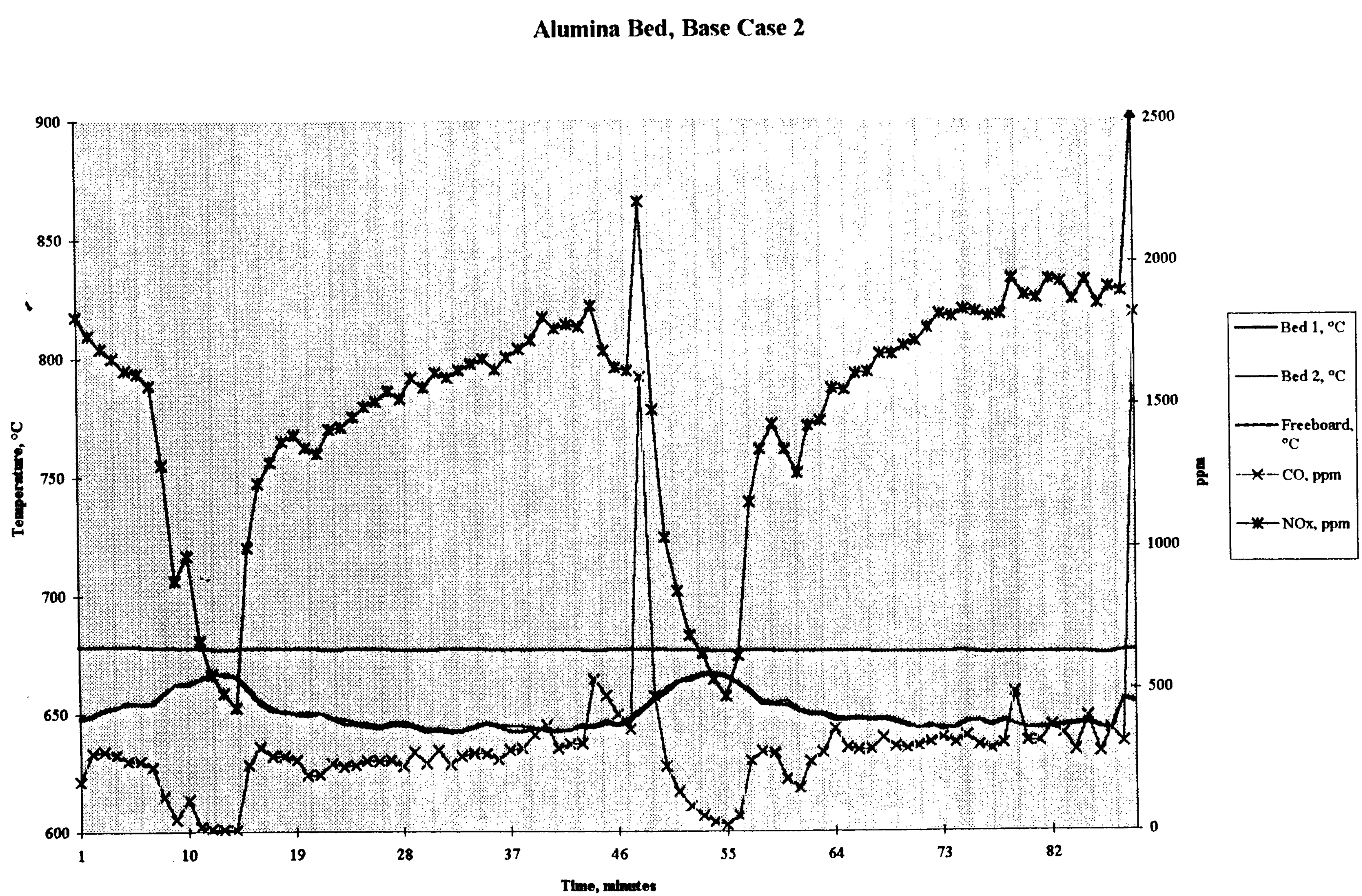
Hazen Research, Inc.

Alumina Bed, Base Case 1



Fluidized Bed Temperature and Offgas Emissions Profile

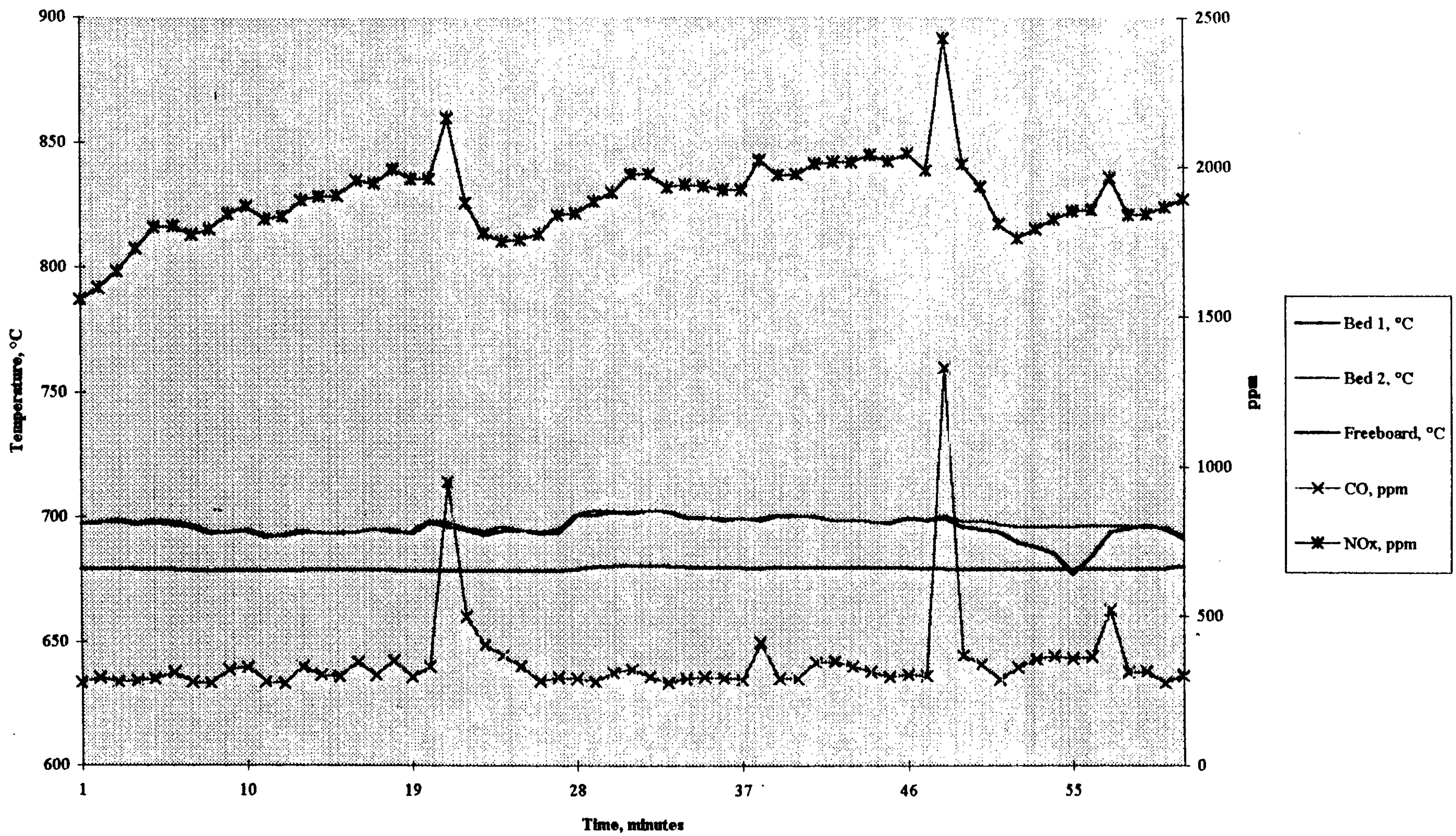
Hazen Research, Inc.



Fluidized Bed Temperature and Offgas Emissions Profile

Hazen Research, Inc.

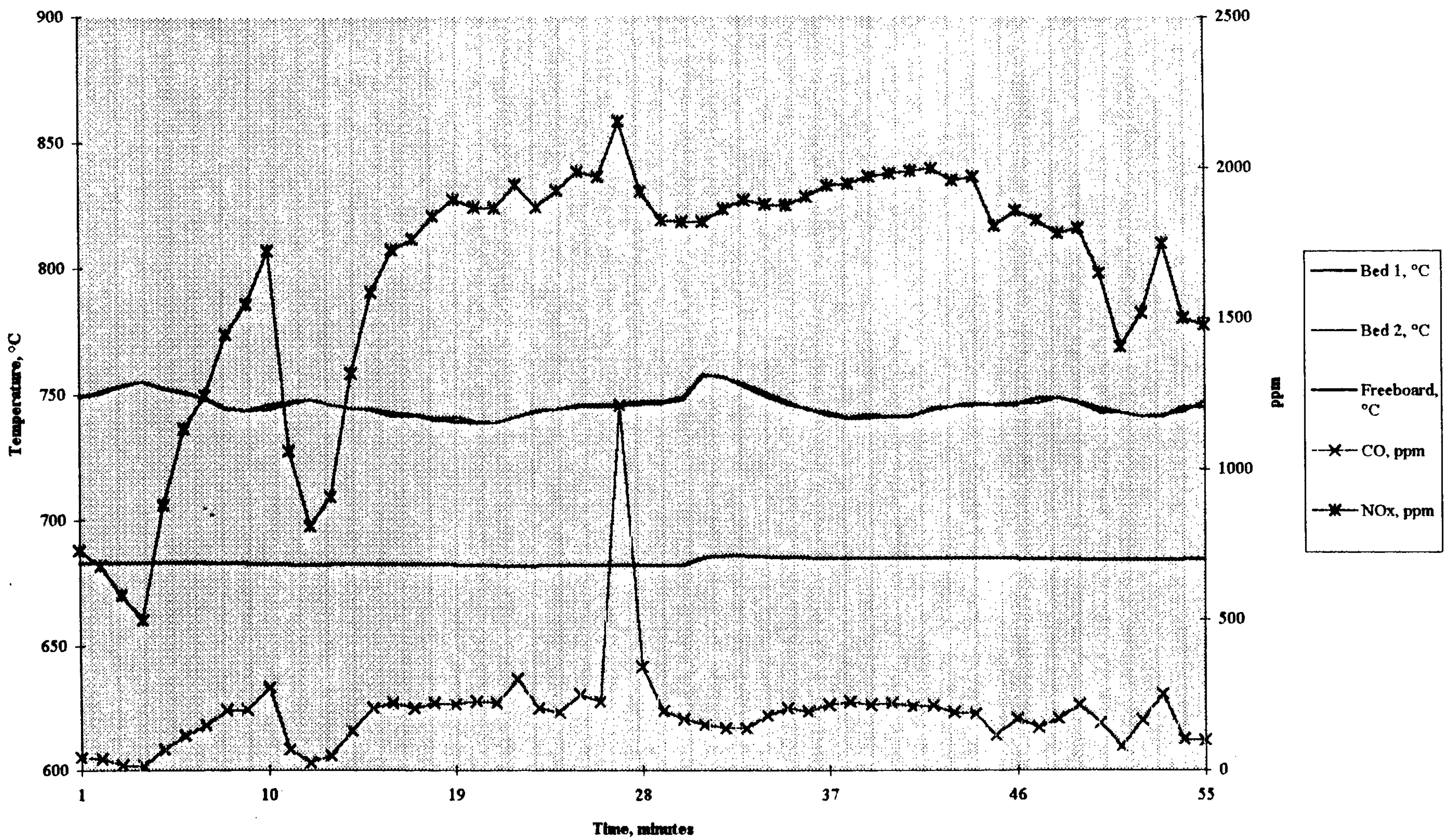
Alumina Bed, Test 1



Fluidized Bed Temperature and Offgas Emissions Profile

Hazen Research, Inc.

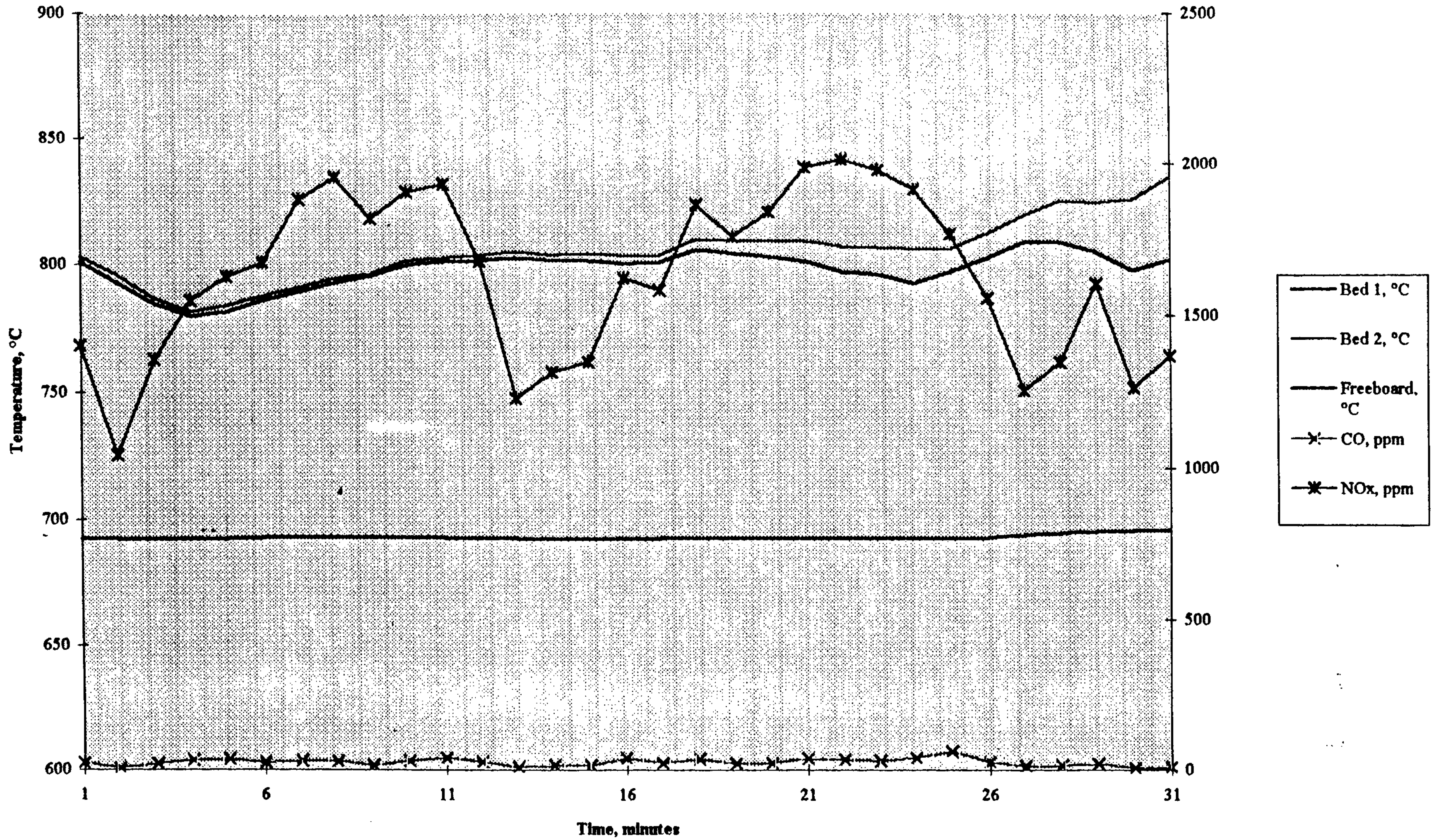
Alumina Bed, Test 2



Fluidized Bed Temperature and Offgas Emissions Profile

Hazen Research, Inc.

Alumina Bed, Test 3



Fluidized Bed Temperature and Offgas Emissions Profile

Hazen Research, Inc.